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Language-Mediated Event Representations

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Declaration

I, the candidate, am the sole author of this thesis. Unless otherwise stated, I have consulted all cited references. The work of which this thesis is a record is my own, unless otherwise stated. The nature and extent to which parts of this thesis are based upon joint research are outlined clearly in-text. The work in this thesis has not previously been accepted for a higher degree.

Glenn Williams, 26th April 2016

Abstract

When understanding narrative events we must keep track of a number of (often) changing dimensions, such as who is the focus of the narrative, what they are doing, and where they are doing it; amongst which, this 'where' dimension is thought to be crucial in forming even the simplest representation of events. Thus, in order to understand how we represent events, research has often focused upon how we represent space. While research from the spatial cognition and language comprehension literature has shown that we can form a mental representation of space that is rich in detail, maintaining categorical (i.e. room-by-room) as well as Euclidean distance (i.e. absolute distance), this research has primarily used tasks which may bias towards one representation over another. Thus, the research presented in this thesis set out to explore which representation of space is maintained in the absence of an overt task, and the implications that this representation has for the organisation and accessibility for information maintained in a mental representation of events (or, an 'event model').

Using eye-tracking methods and 'look-and-listen' tasks in the visual world paradigm throughout to explore how manipulations of space influence accessibility for objects – in terms of fixations on objects depicted in a visual display during language comprehension – the experiments laid out in the present thesis found that comprehenders spontaneously form a categorical (but not Euclidean) representation of space, constructing and maintaining separate 'event models' based around spatial units (e.g. rooms) in which information (e.g. objects) is maintained.

While Experiment 1 found no influence of space on accessibility for the target on mention using a concurrent viewing and listening paradigm, by replacing the visual scene with a blank-screen prior to the onset of the narrative, Experiment 2 established that, during narrative comprehension, following the movement of a protagonist from one location to another, potential targets located in the initial location were less accessible prior to mention for the target. Experiment 3 explored the locus of this effect and found that, on mention, targets were less accessible following a spatial shift, regardless of whether the objects were in the same or a separate location to the protagonist. Experiments 4-6 built upon Experiments 1-3 to further explore how a spatial shift made by an object (carried by a protagonist) can modulate the structure of events, asking how access for a target is resolved when associated with two event models (vs. one event model). Here, visual scenes depicted two rooms, containing

several objects, separated by a boundary. Narratives described an object moving from one location to another with a protagonist, necessitating movement across the boundary (or not). The most reliable finding was that both representations of the moved object were less accessible on mention when associated with two event models (vs. one event model), suggesting that competition occurs between event models prior to access for a target if the target is represented across more than one event model. Experiment 7 aimed to address how event structure can increase, rather than reduce accessibility for a target. Here, discourses separating a target into a different event model (vs. the same event model) to that of a semantically-related competitor increased accessibility for the target on mention and reduced accessibility for the competitor, suggesting that information in an accessed (foregrounded) event model is more accessible than information in other (backgrounded) event models.

Together, the findings of the conducted experiments support the notion that comprehenders form and use event models in discourse comprehension when necessary during passive listening tasks, and that the form and structure of these event models modulates accessibility for information when doing so. The experiments established here have further supported and built upon general models of event cognition, establishing how and when event models, and the information maintained within them, are accessed.

Chapter 1

Representing Spatial Events

1.1. Introduction

Language affords us with the unique ability to create, communicate, and understand a range of experiences unrestrained by our current surroundings. Central to the representations of these experiences are the entities that take part in them, and the events involving and unfolding around these entities. Broadly, events, defined by Zacks and Tversky (2001) as “a segment of time at a given location that is conceived by an observer to have a beginning and an end” (p. 3), are crucial for general human cognition: guiding perception, attention, memory, planning, and decision-making (Radvansky & Zacks, 2014). In language, a representation of events is often required to understand not only what the current state of affairs is, but how this state of affairs has come to be, and why. Yet, even when describing events or states grounded in the here-and-now it is necessary for interlocutors to translate events/states into an internal representation. But what is maintained in these representations? This chapter will provide an overview of how we mentally represent an external state of affairs with particular regard to how we represent events described in language. Starting with an overview of different models for mental representations, this chapter will explore experimental findings in support of a general model for mental representations that goes beyond the surface structure of language.

While we represent events along a number of dimensions, central to our event representations are the two primitives of space and time; without which, even the simplest representation of events is impossible (Radvansky & Zacks, 2014). Radvansky and Zacks argue that within this spatio-temporal representation, space, however, is typically more restrictive and informative, but also less redundant in defining an event than is time and as such is more likely to influence our representation of events than is time. By understanding how we represent spatial events, is it likely that we can understand how we represent events more generally. As such, the literature reviewed here will discuss how we represent events along a number of dimensions, but will focus primarily upon how we mentally represent space during language comprehension. This literature will specifically establish how we update our mental representations as new information is encountered and the consequences this has for accessibility for information from memory. In doing so, this chapter will discuss theories and models for the structure and competition dynamics for mental representations of spatial events, and the outlying issues yet to be explored in the literature.

1.1.1. Mental Models

When reading the words on this page, your aim is to understand the meaning conveyed by the marks on the paper. Although this seems like a deceivingly simple statement, the process by which we understand language involves a number of stages for representation. In doing so, you are attempting to form an internal translation, or representation, of symbols into a working model of understanding in order to draw predictions and make inferences about the incoming text. That is, you attempt to form a mental model of the described state of affairs (Johnson-Laird, 1983). This process for forming internal representations from language is similar to forming internal representations of our surrounding world; in both cases, we attempt to form an accurate model that represents, and is similar in structure to, our physical surroundings. Yet in both, this process necessarily involves some abstraction away from reality. However in the case of language, our mental models are more likely to require elaboration through inference, drawing from our surroundings and prior experience to flesh out the model.

In order to grasp the distinction between our external experiences and our mental models, Johnson-Laird (1983) draws an analogy between our understanding of a clock and our mental model of it. A clock, representing time, is a model of the Earth's rotation, translating one full rotation of the Earth to a full rotation on the face of the clock. Our mental model of the clock needn't be fully accurate or representative of the clock itself for it to be useful; we don't need to understand the mechanics behind the clock as long as the model is sufficient to represent something that tracks time. This is not to say that a mental model is primarily a simplistic reprepresentation of external features. Indeed, our model could be as complex as our understanding of the clock allows it to be. Simply, a mental model acts as a simulation to aid understanding. However, mental models are different to a simulation in that they maintain a similar relation-structure to the phenomena they represent; the mental model is not just an image of an external representation, but it models the underlying principles of that which it represents. To understand the makeup of a mental model it is crucial to delineate how they differ from other types of representations, namely 'mental images' and 'propositional representations'. Johnson-Laird (1983) argues that we can process and encode information using these three different mechanisms, and how we encode information has consequences for accessibility for information maintained in these representations.

Proponents of mental images, such as Shepard (1978) and Kosslyn, Ball, & Reiser (1978) argue that when we imagine something we form a mental image of it that is similar to actually perceiving it. Critically, the mental processes for representing a mental image are thought to be similar to that for actually experiencing it. These mental images represent what they intend to in a one-to-one manner, for example, when we imagine a spatial array of objects those objects and their spatial relations should be represented in an anological manner. Further to this, although we can manipulate our view of a mental image, for example, by mentally rotating objects in space, these manipulations must maintain the integrity of the mental image in relation to perceptible changes. Johnson-Laird (1983) argues that these mental images form the basis of a view from a mental model; they represent the external structures of what they intend to represent, but they cannot represent the content of them. Further the mental model can be formed from inferences and assumptions, and can be used as an exemplar for a general class of entities, whereas the image cannot. Proponents of propositional representations, such as Pylyshyn (1973), however, argue that propositions form the basis of mental images, and that mental images are not sufficient to explain how we represent abstract concepts. In this account, representations are not made of pictures or words; instead they are represented by a network of propositions. These propositions are abstract and amodal and discretely represent explicit relations between other propositions. Inkeeping with these claims, propositions do not directly represent what they intend to, but instead the propositions can be true or false for a given state of affairs. Early propositional models of language comprehension (e.g. Kintsch & van Dijk, 1978) argued that when we attempt to represent the content of language we do so by constructing a text-base, which is a representation of the linguistic input in the form of a propositional network, using short-term memory to maintain the incoming information to build a realised model of the text. When understanding language, we form a proposition by integrating predicators with arguments in a similar structure to that presented in Example 1.1, adapted from Sanford and Garrod (1981):

Example 1.1. The structure of a proposition

(Predicator, Argument$_1$, Argument$_2$, … Argument$_n$)

To take an example from Sanford and Garrod, when understanding a simple phrase such as ‘John sleeps’ we would form a propositional representation such as that presented in Example 1.2, adapted from Sanford and Garrod (1981):

Example 1.2. Forming a propositional representation from a simple phrase

(SLEEPS, JOHN)

In order to understand more complex texts, several different propositions can be embedded within one another to form a coherent representation. Taking the claims made by propositional and imagistic psychologists into account, several studies have explored the types of representations formed during language comprehension. Although imagistic and propositional psychologists initially took opposing views for the basis of a mental representation, the results of several studies have shown that we can form both propositional representations and mental models under different circumstances. One implication of the claims that mental models are based on views from mental images is that mental models necessarily rely on exemplars; we cannot have a general model for, say, a thesis or a viva voce, but we rely on an archetype for each token in this representation. Similarly, in a mental model we cannot have an indeterminate representation for a description of an indeterminate spatial arrangement of objects. Instead, we must commit to one possible representation to form a mental model of a spatial layout. Yet, Pylyshyn (1973) argues that a propositional representation can handle such indeterminate representations. Mani and Johnson-Laird (1982) tested such claims across two experiments to establish whether propositional representations were sufficient alone in representing spatial relations. In this experiment, participants were given instructions describing a layout of several objects before viewing a spatial layout and ranking how well it fit the description. Across items, the layouts for these objects could be described in a similar manner to that in Example 1.3:

Example 1.3. An example of the determinate descriptions used in Mani and Johnson-Laird (1982)

1. A is to the left of B
2. C is to the right of B
3. D is in front of A
4. E is in front of B

The above example uses a determinate description to describe the layout of the objects; the layout of these objects could only be (correctly) interpreted in the form of Example 1.4:

Example 1.4. The correct layout for the determinate descriptions used in Mani and Johnson-Laird (1982)

D	E	
A	B	C

However, a minor change to the second statement could result in an indeterminate description of the layout, in which more than one possible layout could be interpreted from the instructions, as depicted in Example 1.5:

Example 1.5. An example of the indeterminate descriptions used in Mani and Johnson-Laird (1982)

1. A is to the left of B
2. C is to the right of A
3. D is in front of A
4. E is in front of B

Two possible inferences can be made for the layout of the objects, one the same as the determinate layout in Example 1.4, and one such as that depicted in Example 1.6:

Example 1.6. One potential layout for the indeterminate descriptions used in Mani and Johnson-Laird (see Example 1.4 for the other potential layout)

D		E
A	C	B

On each trial, participants were asked to rank four descriptions for the spatial layouts on how well they fit the initial descriptions provided during encoding. Participants were given the original description, an inferable description (i.e. changing the first sentence to ‘D is to the left of E’), and two descriptions that did not fit the layout. The results showed that participants tended to remember determinate descriptions better than indeterminate descriptions when provided with both the original and inferable descriptions. However, the original description was often ranked higher than the inferable description when an indeterminate description was used during encoding. These results suggest that when we are provided with detailed (determinate) descriptions, we are likely to build and rely upon a mental model; we are more likely to accept inferable descriptions as being accurate to our representation even when this doesn’t fit the original description’s linguistic form. Yet, our mental models do not encode much of the linguistic form from encoding. However, when given indeterminate descriptions, such as in cases when we have two possible layouts – and thus two possible mental models – we are likely to rely on a propositional representation of the described layout. In this case, we are more likely to remember the original structure of the words (i.e. verbatim), but this comes at a cost for memory for the described state of affairs in general. When a mental model is used, the spatial layout is likely easier to recall in general as mental models require more elaboration and deeper processing in order to construct a coherent imagistic mental representation (Bower, 2008; Craik & Tulving, 1975).

When the form of a model is initially indeterminate, we often have difficulty in integrating information into a coherent model. This was evidenced by Ehrlich and Johnson-Laird (1982) who asked participants to make drawings based on the spatial layouts of three sentences such as that depicted in Example 1.7:

Example 1.7. An example of the descriptions of the layout used in Ehrlich and Johnson-Laird (1982)

1. The knife is in front of the pot.
2. The glass is behind the dish.
3. The pot is on the left of the glass.

Because the spatial layouts were described in a discontinuous manner, in that they did not follow from one sentence to the other linearly, the percentage of correct drawings from layouts was relatively low (33%). However, if they were presented continuously (i.e. reading in the following order: 1, 3, 2), the percentage of correct layouts in drawings was increased (57%). Remembering spatial layouts from discontinuous descriptions is particularly difficult because separate models must be built and maintained as the instructions unfold. In order to understand the full spatial layout in the above example, the separate models built up from sentence 1 and 2 must be integrated into a single model in light of sentence 3. This integration or model updating process should be costly in terms of mental processing when using a mental model. Otherwise, it is possible to build up a propositional representation of each individual sentence prior to forming one model after acquiring all information; however as has been discussed earlier, this mechanism for representation is often taxing in itself. Such results are reported not only in drawing tasks but also for reading; when we encounter a discontinuous narrative, reading-times often increase (Ehrlich & Johnson-Laird, 1982). Across these studies, it can be concluded that if a described layout does not agree with our model, or if we are unable to form a coherent model in the first instance due to a lack of evidence then we are likely to have difficulty in remembering information from text. But if we are able to form a coherent model we are more likely to remember the described state of affairs. Furthermore, it is apparent that we attempt to form a coherent mental model online; if we have to wait to accrue all incoming information, formation of mental model becomes less likely. These findings have been instrumental in inspiring a number of a studies exploring how we structure a mental model and the consequences this has on memory for information represented in these models.

When making implicit inferences from language, our ability to form accurate mental models is crucial to our understanding of a narrative. Oakhill (1982) compared children with equal vocabulary and reading skills, but different levels of text comprehension. Here, children were split into two groups; those with a high-level of text comprehension (*M* age = 7.67) and those with a lower level of text comprehension (*M* age = 7.72). Children read narratives such as that depicted in Example 1.8:

Example 1.8. An example of the narratives used in Oakhill (1982)

1. The car crashed into the bus.
2. The bus was near the crossroads.
3. The car skidded on the ice.

Children with higher levels of story comprehension were found to mistakenly assume that ‘The car was near the crossroads’ occurred in the story; whereas they were less likely to assume that ‘The bus skidded on the ice’ occurred. As such, mistakes made by those children with higher levels of story comprehension were more likely to be consistent with the mental model. Also, those children with a higher level of text comprehension were more likely to remember the original story than those with a lower level of text comprehension. This is primarily due to the plausibility for these two events within the narrative in the first instance. If we can form an accurate representation of events in the story, the first statement fits with the mental model, but the second does not. In the second instance, it is likely that children with higher levels of story comprehension were more likely to recall the correct story segments as they formed an accurate mental model of the story. In the children with lower levels of text comprehension, it is possible that a propositional representation of the text was relied upon; a representation that is vulnerable to forgetting (Johnson-Laird, 1983; Kintsch, 1988; Sanford & Garrod, 1981). Critically, this research shows that mental models are abstractions from language that represent a specific state of affairs informed by general knowledge and elaborated through inference; we often lose any details about the surface structure of language when we attempt to understand a story. Indeed, comprehenders are often more sensitive to changes in the content of a text, not the verbatim structure, after a short delay between comprehension and tests of recognition (Sachs, 1967).

Mental models are crucial to language comprehension in that they allow us to make inferences beyond the surface structure of language. When, for example, understanding a narrative, text (or discourse) is represented on a number of levels. First, a text-base is *constructed* from the incoming language and from the comprehenders' external knowledge. This text-base takes the form of a propositional network derived from a surface model of the word meaning and syntax of incoming language, as well as any inferences drawn from these sources. These sources of information are then *integrated* into a situation model that represents the described state of affairs. Here, the surface structure of language is lost, with the gist of described events remaining. This process forms the basis of the construction-integration model for language comprehension (Kintsch, 1988); a model that builds upon work on propositional representations and mental models to account for general representations formed through language.

Similarly to Johnson-Laird's (1983) framework for mental models, the construction-integration model (Kintsch, 1988) accounts for a number of findings that cannot be explained by propositional representations of language alone. For example, when presented with short texts such as 'The housewife cooked the chips', the verb *fried* is more effective than the more general verb, *cooked* for cued recall tasks (Garnham, 1979). With a propositional account of language comprehension (e.g. Pylyshyn, 1973), text would be represented in a typical argument structure such as (COOK, HOUSEWIFE, CHIPS). In this case, it is unclear how a more specific verb, such as *fried* could be incorporated into the propositional network. With a mental model account, the verb *fried* maps onto our internal representation of the text better than cooked. Using this mental model as a means for recall, it becomes clear why a more specific verb may act as a better cue for recall than the general verb (Sanford & Garrod, 1981). However, a propositional representation of the text is often enough to understand the relationships discussed in the story. As such, Kintsch proposes a model for language comprehension in which the surface structure of language is maintained in working memory in tandem with the comprehenders' knowledge-base, from which a propositional representation of the text-base is derived and inferences are formed. This propositional representation consists of the relations between the predicate and concepts in the text-base. These propositions are then used in turn with general knowledge to represent what the text is about in a mental model of the text, or a *situation model*, as termed by van Dijk and Kintsch (1983). The situation model is “a mental representation of a described state of affairs that serves as a mental simulation of those events” (Radvansky, 2009, p. 796). Crucially, the situation model is informed and constrained by general knowledge about words, syntax, and our external experiences, allowing us to only form representations that are appropriate in the given context; with violations to these representations requiring reconstruction in order to form a more appropriate situation model (Kintsch, 1988). Constraints are necessarily placed on situation models through their structure; aside from general cognitive demands associated with maintaining a representation in working memory, the form and structure of a situation model may influence accessibility for information maintained within it. As such, studies building upon the models proposed by Johnson-Laird and van Dijk and Kitsch have explored what is represented in a situation model.

The majority of work exploring different types of mental representations has often focused upon mental models formed from language, with Johnson-Laird's (1983) general model for representation being supported primarily by work on language comprehension. Here, a similar distinction is made between different types of mental models to that suggested by Radvansky and Zacks (2011). Although similar in form, Radvansky and Zacks make the distinction between different types of mental model: A mental model is a representation of a state of affairs that can be tied to a specific event or not. If a mental model is not tied to a specific state of affairs, it is referred to as a systems model. These systems models can be either physical or abstract. In this case, imagine the clock described in the earlier example, or the concept it aims to measure, time. If mental models are tied to a specific state of affairs, this is labelled an event model. If an event model represents a state of affairs derived from live experience, this is termed an experience model. If, however, it is derived from language, it is termed a situation model (e.g. van Dijk & Kintsch, 1983). Both types of event model capture the entities and relations between entities maintained within them and it is thought that the structure of both types of model is functionally similar (Radvansky & Zacks, 2011). Indeed, event segmentation theory (EST: Radvansky & Zacks, 2011), a model of how we interpret and segment incoming streams of information into separate events, draws on research and theory from the narrative comprehension and memory literature, namely from the Event Indexing Model (Zwaan, Langston, & Graesser, 1995) and from a series of experiments run by Gordon H. Bower, Mike Rinck, and colleagues (e.g. Bower & Morrow, 1990; Morrow & Bower, 1989; Morrow, Greenspan, & Bower, 1987; Rinck & Bower, 1995). With event comprehension forming the core of human experience, be this through real-world experience or through language comprehension, this thesis will focus upon how we mentally represent events. Focusing primarily upon situation models, this chapter aims to discuss how mental representations of events differ from perception, and the influences this has on recall for represented events. Section 1.1.2 will build upon the present section, focusing primarily upon how we understand and integrate different sentences into a coherent representation of events, exploring how the structure of a situation model can influence language comprehension.

1.1.2. Spatial Situation Models

When forming a situation model, we rely on a set of cues from language in order to construct a representation of the described state of affairs. The Event Indexing Model (Zwaan et al., 1995) argues that to do so, we must track the events and actions of characters along a number of dimensions, of which time, space, causation, intentionality, and protagonist were explored. Using a word-clustering task, Zwaan et al. gave participants short narratives to read. These narratives related to a fictional story of three sisters being kidnapped by a dragon before being rescued by three heroes. Within these narratives, verbs were identified that only occurred once within the story. Shortly after reading the narrative, participants were tasked with grouping verbs they thought belonged together based on the narrative, for example deciding whether the verbs ‘dragging’ and ‘crying’ were similar to each other or not. Crucially, participants could do this either with the text present or without the text (i.e. from memory). Here, it was predicted that with the text present comprehenders would have a better opportunity to construct a situation model. As such, it was predicted that the five dimensions of time, space, causation, intentionality, and protagonist would be better predictors for the verb clustering task with the text present (vs. absent).

The surface distance (the number of intervening words between two verbs), surface connections (whether two verbs were a part of the same sentence), and argument overlap (whether two verbs share the same argument) were reliable predictors for scores in the verb-clustering task mainly when the text was present for participants during the task. The lexicon was also found to be a reliable predictor for scores, however this was primarily when making judgments from memory (i.e. in the absence of the text). Most importantly, the situation model was found to be a strong predictor for the verb-clustering task regardless of whether the text was present or absent. Together, these results support the models laid out by Johnson-Laird (1983) and van Dijk and Kintsch (1983), showing that multiple representations can be formed and used when processing narratives, but also that the situation model exerts a strong influence on verb clustering – and thus our interpretation of narratives – regardless of whether the context biases towards the use of a situation model or not. Importantly, this study has also highlighted the different dimensions that can be maintained independently in a situation model; time, space, causation, intentionality, and protagonist indeces were found to independently influence event comprehension.

Prior to the proposal of mental models or situation models, Bransford, Barclay, and Franks (1972) explored how our mental representations of described events can influence memory for those events. In this study, participants listened to sentences such as 1a and 2a in Example 1.9.

Example 1.9. An example of the sentences used in Bransford, Barclay, and Franks (1972)

1a. Three turtles rested *on* a floating log, and a fish swam beneath *them*.
1b. Three turtles rested *on* a floating log, and a fish swam beneath *it*.
2a. Three turtles rested *beside* a floating log, and a fish swam beneath *them*.
2b. Three turtles rested *beside* a floating log, and a fish swam beneath *it*.

After hearing one of these sentences, participants were given a recognition test containing sentences such as 1b and 2b. Bransford et al. found that participants were more likely to misremember 1b as 1a, accepting it as the first sentence they listened to. However, if participants first heard 2a, they were unlikely to accept 2b in the recognition test. Although the change in surface structure between 1a-1b and 2a-2b pairs is the same, only changing the pronoun *them* to *it*, our mental representation is very different across the pairs. In 1a and 1b, the spatial layout described is equivalent; in both cases a fish swims beneath a log with three turtles ontop of the log. However, 2a describes a fish swimming beneath three turtles that are rested beside a log, whereas 2b describes a fish swimming beneath a log which has three turtles beside it. Thus, we find it difficult to differentiate between 1a and 1b as they both represent the same spatial layout and the same state of events, wheras the spatial layouts in 2a and 2b differ, and thus the representation of the state of events differs. Similarly to research carried out by Oakhill (1982), when accessing the described state of events, it is likely that the structure of the situation model, and not the surface structure of the language, will be remembered. This results in confusion when remembering which sentence was first presentend if the described events are equivalent. However, of note here is that the spatial relations amongst referents within the situation model are maintained. Thus, some representation of spatial features is both represented and influential for comprehension.

Further studies have shown the consequences of using a situation model for representation on memory for the information maintained within it. Anderson et al. (1976) presented participants with sentences such as ‘The fish attacked the swimmer’. They found that when asked to recall the sentence, recall was better when given a specific cue such as *shark* instead of the more general, but original term of *fish*. This is thought to be because situation models are specific instantiations of a described state of affairs. In this case, the situation model likely used general knowledge to flesh out the representation of the fish as one that would be likely to attack a swimmer. As such, using a specific term of a man-eating-fish should be a better cue for recall from the specific situation model. Another study by Johnson, Bransford, and Solomon (1973), further established how the implications drawn from a sentence can influence what is remembered from the sentence itself. In this experiment, participants were presented with sentences such as those depicted in Example 1.10.

Example 1.10. An example of the sentences used in Johnson, Bransford, and Solomon (1973)

> 1a. When the man entered the kitchen he slipped on a wet spot and *dropped* the delicate glass pitcher on the floor…
>
> 1b. When the man entered the kitchen he slipped on a wet spot and *just missed* the delicate glass pitcher on the floor…
>
> 2. When the man entered the kitchen he slipped on a wet spot and *broke* the delicate glass pitcher on the floor…

Johnson et al. (1973) found that if participants heard sentence 1a rather than sentence 1b, they were more likely to accept sentence 2 as one they had initially heard. Similarly, when given a picture that makes sense in relation to a following story, participants are more likely to remember the contents of the story (Bransford & Johnson, 1972). In doing so, the picture provides context for the situation model, allowing information to become entrenched and thus more accessible after processing. Comprehenders rely on these representations when remembering information, with greater memory for information concordant with these representations. As such, a situation model is not only fleshed out by inference from language, but also by details outwith the language itself.

When forming a mental model from language we essentially rely upon an impoverished and linear mechanism with which to comprehend the details of a non-linear reality, often relying upon context-dependent expressions (Spivey-Knowlton, Trueswell, & Tanenhaus, 1993) and inferences derived from real-world experiences (Barsalou, 1999) to elucidate events; that is, we have to ‘fill in the gaps’ when forming a situation model from language. Yet, using an interactive process in which we draw upon information obtained from previously-encountered linguistic (Radvansky, 2009) and non-linguistic domains (van Dijk & Kintsch, 1983), we are able to create a suitable mental representation of language that is analogous to actually experiencing an event (Glenberg, Meyer, Lindem, & Lindem, 1987). Critically, these models are deemed to be perceptual-like, in that a mental model derived from language need not be any different from a mental model derived from experience (Glenberg et al., 1987). While this claim that mental models are 'perceptual-like' is rather vague, in the present thesis this claim is interpreted to mean that 'viewing' a mental model is similar to viewing events unfolding in real-time; that is, our interpretation of events should be similar regardless of whether they are formed from language or experience. However, this claim also has important ramifications for how we interpret mental models in the literature: While our interpretation of the events may be similar regardless of the modality of encoding, given that a mental model is an abstraction from reality filled in by our own background knowledge and inferences, we must ask to what extent are mental models similar in form and structure to the real world? And how does the structure of a mental model influence our ability to access information maintained within these representations? These two research questions form the stimulus to the experiments later outlined in this thesis.

If mental models are similar regardless of whether they are formed from language or experience, this affords us with a range of paradigms with which to explore the questions laid out above. As noted earlier in this chapter, an understanding of how space is represented is crucial to understanding how we represent events in a broader sense. Moreover, in language research space is a convenient avenue for exploring the structure of a situation model given that we can readily manipulate the spatial makeup of a representation while controlling for the surface structure of the language (Zwaan & Radvansky, 1998). In order to understand how we represent space during narrative comprehension we must first understand what is maintained in a general mental representation of space, and how this information is organised. Turning to the spatial cognition literature may thus provide insights into how space is represented from perception, highlighting any similarities and differences between the organisation of space in mental imagery and mental models; between perception and 'perceptual-like' representations.

In mental imagery tasks, participants are asked to recall only information that was perceptually available, forming a mental image akin to a "quasi-pictorial representation" (Rinck & Denis, 2004, p. 1211), and free from subjective biases. In this sense, these mental images differ from a mental model. Mental representations formed this way have been found to maintain detailed spatial information. By using a visual scanning task, in which participants learn a visual configuration, reconstruct its visual appearance through mental imagery, and scan through the representation to retrieve objects, Kosslyn, Ball, and Reiser (1978) found a correlation between the Euclidean distance (i.e. absolute distance) between two objects in a visual scene and the accessibility for object pairs. As the distance between two objects increased, the speed with which participants responded to probes for object-pairs increased. However, this effect was only found when participants were instructed to form and base their judgments on a mental image. Yet, our representations of space and spatial relations do not only consist of estimations of distance in a Euclidean sense, but we also maintain some representation of intangible boundaries between locations. Stevens and Coupe (1978) found that our judgments for the spatial relations between locations can be distorted by the presence of a boundary between locations, be these either geographical or political boundaries. Crucially, Stevens and Coupe also found that the spatial relations between two locations were only maintained for location-pairs within boundaries, suggesting that a representation of Euclidean distance between two locations is only likely to be maintained if the two locations are part of the same super-ordinate region, or *categorical* location. In a similar vein, Hirtle and Jonides (1985) used an ordered-tree algorithm developed by Reitman and Reuter (1980) to observe how spatial memory was structured for natural environments. Hirtle and Jonides found that participants both underestimated distance judgments for landmarks within the same cluster, and overestimated judgments for landmarks between different clusters. Together, these studies support a model for the representation of space that is neither purely Euclidean nor purely categorical. We can represent space both in terms of superordinate categorical groupings and in terms of the metric distance between locations – be this either within or between categorical regions.

Although it seems that we can produce and maintain a representation of space that includes Euclidean and categorical metrics of space, the question remains how these representations are organised. Strongly hierarchical theories of spatial memory presume that spatial representations are subserved by nested levels of detail and that our representation of space is arranged according to order of containment (e.g. buildings within an estate, rooms within a building), with no spatial relations between locations being held in memory. In order to understand the distance between two locations, inferences must be made based on the relative positions of locations within a category (e.g. the relative positions of rooms within a building); mental representations of distance must be computed (McNamara, 1986). Conversely, non-hierarchical theories (e.g. Byrne, 1979; Kosslyn et al., 1978) assume that all spatial relations are represented at the same level. Yet, some middle-ground between these two theories was found to be the most plausible explanation for mental representations of space. This partially-hierarchical account (McNamara, 1986; McNamara, 1992; Stevens & Coupe, 1978) argues that spatial relations are encoded at different levels along an order of containment, but spatial relations can be encoded between information maintained across different levels (i.e. both within and between different locations). Support for this notion was evidenced by McNamara (1986), who conducted a study in which participants memorised two spatial layouts of objects split into four quadrants; one through physical experience and one via a map. In both cases, following memorisation of the objects, participants took part in a recognition test for the objects learned, judgments of the direction of objects in relation to another object, and an estimation of the distances between objects. The most striking results showed that objects were recognised more quickly when primed by an object in the same region (vs. a different region) and when it was primed by a close (vs. far) object. Critically, this distance effect persisted for judgments of objects across boundaries. Further, participants typically overestimated judgments of distances between objects located in different regions, and underestimated the distances between objects located within the same region. Thus, categorical spatial information is used in grouping objects and directly influences accessibility for the objects, even if the spatial relations between objects in different categories are maintained. McNamara (1986) thus proposed a model for how spatial relations are represented in memory whereby the spatial relations between objects and boundaries are encoded. Crucially, in this model it is hypothesised that the probability with which these representations decay from memory is greater for spatial relations across boundaries than within them. At a higher level, each object is encoded as part of a given region, with links specifying the relationship between locations and regions. At the highest level, each region is represented in part of a spatial layout. Thus, during mental imagery, both Euclidean and categorical representations of space are maintained and influence accessibility for what is represented. The question remains, are mental models structured in a similar way? Can both categorical and Euclidean distance be maintained?

1.1.3. The Metrics of Spatial Situation Models

Whilst representations of space from experienced or imagistic sources have been shown to maintain Euclidean distance, they are nonetheless an abstraction away from the state of the real world, with additional groupings based around regional or spatial boundaries (amongst others). If these direct representations are essentially distorted or manipulated representations of space in the real world, how is space represented when details must be filled in by the comprehender? When understanding narrative events, through necessity we often have to fill in such details in regards to the spatial relations described amongst referents. In doing so, how much detail is maintained in these representations? During narrative comprehension, spatial representations have been found to influence our ability to access information from within a narrative when explicit focus is not given towards the particular layouts of objects. One study by Glenberg et al. (1987) explored the influences of spatial representations in regards to memory for information maintained in a situation model. Participants read sentences in which a protagonist was either spatially associated or dissociated with an object (e.g. 'John put on/took off his sweatshirt before going jogging.'). The aim of this study was to explore whether or not this association with a protagonist made the object (i.e. the sweater) more accessible through foregrounding. Following Sanford and Garrod (1981), it was assumed that maintaining a representation of an object in close proximity to the protagonist would keep said object in explicit focus – making said object more accessible. This is likely due to comprehenders generally focusing upon the protagonist and their goals and relations among other entities during comprehension (Rapp, Klug, & Taylor, 2006). In their study, Glenberg et al. assumed that the protagonist would be foregrounded through pronominal reference across all items in their three experiments.

In their first experiment, Glenberg et al. found that participants were slower in responding to recognition probes to indicate whether an object was mentioned in the previous sentences when the object was dissociated from (vs. associated with) the protagonist. A second experiment addressed concerns that the differences across conditions reflected differences in lexical access rather than foregrounding. In this experiment, the item recognition task was replaced by a lexical decision task in which participants responded 'yes' if the target was a word, and 'no' if not. The findings of this experiment showed that there was no difference between the associated and dissociated conditions in terms of lexical access, confirming that this difference in accessibility was not driven by differences in lexical access across conditions. Finally, a third experiment observed the effects of foregrounding during online language comprehension. In this experiment, participants read a critical sentence describing a protagonist picking up or putting down an object before moving to a new location (e.g. ‘He picked up/set down his bag and went over to look at some scarves.’). Following no delay or a delay of one filler sentence, a test sentence referred back to the target object (e.g. ‘He thought it was getting too heavy to carry.’). After reading the discourse, participants had to verbally respond what they thought ‘it’ referred to in the final sentence to ensure participants resolved the narrative in both conditions. Crucially, participants read the sentences faster if the object was associated with the protagonist (vs. dissociated), and read the sentences faster if no delay occurred between the test sentence and the critical sentence (vs. 1 filler delay), and further found that a delay was more deleterious for reading times in the dissociated condition (vs. the associated condition), suggesting that foregrounding modulates the level of accessibility of a target during discourse processing, but also that this effect is long-lasting. Under the assumption that an increase in response/reading times reflects accessibility for representations, these results indicate that foregrounding through spatial association allows for information with a narrative to remain highly accessible, and information in the background, less so.

A number of assumptions about the nature of a mental model can be drawn from the results of Glenberg et al. (1987): (1) We often focus upon the protagonist during narrative comprehension, with information associated with the location where the protagonist is being foregrounded, or highly accessible; (2) We segment information into separate models when a shift in space is encountered; and (3) When a shift is made to a new location, information that was relevant prior to this change in space (i.e. in a different model) is less accessible. Together with the findings of Ehrlich & Johnson-Laird (1982), it becomes clear that a mental model, and in particular, a situation model, is a “representative sample from the set of possible models satisfying the description” (Johnson-Laird, 1983, p. 165). We can only form and use mental models when they pertain to a single possible representation. When the representation is indeterminate in regards to a single model we are likely to utilise a propositional-based representation, rather than a mental model, as it is unlikely that we will construct and utilise all possible mental models. Thus, it is likely that, as we form a model, we create one based around what is most likely correct given the current evidence (i.e. based on language, experience, and inferences), and update the model only when necessary (Johnson-Laird, 1983). When evidence is encountered that renders the current model inaccurate, the model will be reconstructed to satisfy the current conditions. Indeed, mental models are not static, instead they are continually updated as more information and evidence is accrued, updating the model as discourse unfolds rather than waiting until the end of a sentence to do so (Garnham, 1985). It is hypothesised that we use these models to predict and interpret the following sentence, relying on both linguistically-based and real-world knowledge to support the mental model (Radvansky & Zacks, 2014).

For example, if I mention a model in the context of this thesis, you will (often) correctly infer that the referent is a mental model, not say, an attractive person; you use the given context to structure your representation, and this bias towards the most probable representation influences accessibility for said representation and the other possible meanings. Indeed, if the text disambiguated this model to refer to a person, our mental model could be manipulated to account for the change in definition; thus, mental models are both updateable and manipulable (although updating a model often comes at a cost) (Radvansky & Zacks, 2011). It is argued that when understanding a narrative, the dimensions outlined by Zwaan et al. (1995) are indexed as they are encountered, and are monitored in relation to incoming information. Continuation of activation for these indeces is thought to be the default state during processing. When a change occurs along any of these dimensions, the index for that dimension is updated. When this happens, the current representation is deactivated and a new one is activated (or, an even older representation is reactivated). This process of deactivation and (re)activation is costly, associated with an increase in reading times for sentences with changes along these dimensions; the more changes encountered along these dimenions, the longer the reading times.

A series of experiments by Rinck, Bower and colleagues (Morrow, Greenspan, & Bower, 1987; Rinck & Bower, 2000; Rinck & Bower, 1995) aimed to explore how mental models are updated as changes occur along a spatial dimension. Building upon the results of Glenberg et al. (1987), these experiments aimed to explore how representations of space can be updated during narrative comprehension. A central question to this research was how information becomes less accessible as a shift is made to a new location, asking whether information outside of the working foregrounded situation model becomes less accessible as the distance between a protagonist and object increases. Most of the research in this series of experiments built upon that of Morrow et al. (1987) in which participants first memorised a map of a building made up of separate rooms containing objects. Once the map and its contents were memorised (see Figure 1.1: used in Rinck & Bower, 1995), participants read a narrative describing a protagonist moving along a path through the rooms within the building, including a critical sentence that described the source and goal locations associated with the completed motion of a protagonist (e.g. 'Wilbur walked from the conference room into the laboratory.') and sentences following this describing the actions of the protagonist in the goal location.

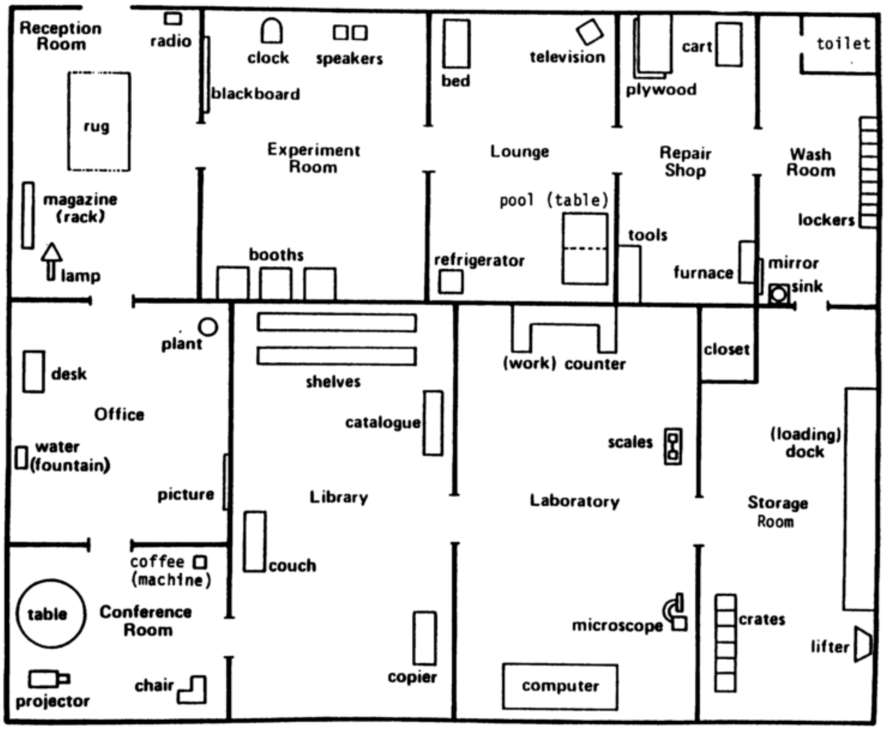

Figure 1.1. Building layout memorised by participants in Rinck & Bower (1995)

Participants were probed with pairs of object names following the critical sentence and were tasked with indicating whether these objects were contained within the same or different locations by a button response (e.g. Morrow et al., 1989, 1987; Rinck & Bower, 2000). It was found that response times (Morrow et al., 1987) and later reading times (Rinck & Bower, 1995) were fastest when an object was located in the same room as the protagonist, slower when objects were located in a previously entered room or a room along the path of the protagonist (Morrow et al., 1987; Rinck & Bower, 1995), and slower still when rooms were not immediately relevant to the protagonist (e.g. Rapp et al., 2006). Such effects persist even when a protagonist never physically interacts with an object within the narrative, but instead simply *thinks* about objects (Morrow, Bower, & Greenspan, 1989). These results were initially taken in support of situation models being similar to mental images in their representation of space.

Together, the results from the situation model and mental imagery literature have been seen to support a Euclidean (i.e. continuous interval scale) or *gradient account* for the mental representation of distance, in that the further away a protagonist travels (in a Euclidean sense) from a referent, the more difficult it becomes to access the object. However, Rinck, Hähnel, Bower, and Glowalla (1997) note that most researchers either implicitly or explicitly assume that spatial situation models represent Euclidean distance. They ask, does accessibility for an object decrease as the distance between the object and protagonist increases on a continuous interval scale (e.g. Euclidean distance), or on an ordinal scale (e.g. the number of rooms passed through: henceforth *categorical distance*), as highlighted by the previous research by Timothy P. McNamara (e.g. McNamara, 1986)? It is plausible that the aforementioned results could be driven not by an increase in Euclidean distance between a protagonist and object, but by an increase in the categorical distance between the two. In an effort to delineate the metrics of space, Rinck et al. (1997) used a similar method to that used by Morrow et al. (1987) and Rinck and Bower (1995), in that participants memorised a map (e.g. Figure 1.2) prior to reading anaphoric sentences which made reference to objects contained within rooms. Across three experiments, the size of the rooms and the number of boundaries between locations within the map were manipulated independently such that one room could be very large but equivalent in size to two rooms separated by a boundary, thus allowing for inferences to be made about whether Euclidean or categorical distance differentially influences accessibility for referents. After reading a series of sentences which set up the initial location of the protagonist and made reference to the surrounding objects, participants then read a sentence describing the protagonist moving from this initial location to a final location (e.g. describing movement from the storage room into the lounge).

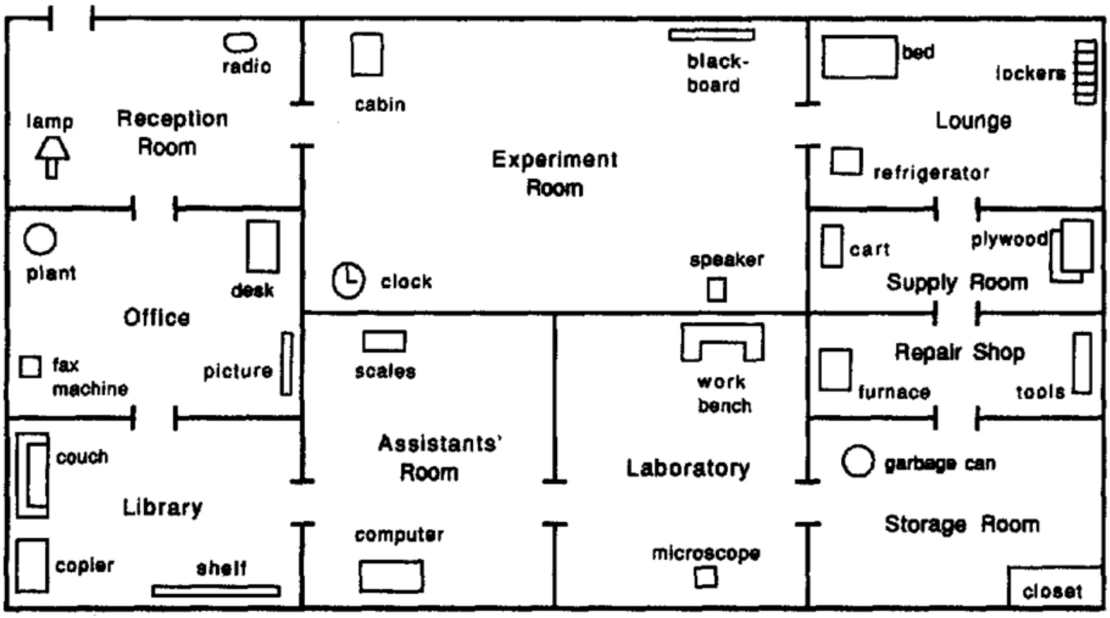

Figure 1.2. Building layout memorised by participants in Rinck et al. (1997)

In their first two experiments, it was found that upon reading an anaphoric sentence which made reference to an object either in the initial location, the near and far path rooms, or the goal room that an increase in categorical, but not Euclidean distance led to an increase in reading times. Moreover, a series of further experiments confirmed that, while the distance between referents in the surface structure of text can influence accessibility for objects, this only has an effect when strong surface cues are available. Yet, as the distance between referents increases in the situation model, accessibility for the target object decreases even when controlling for the distance between referents in terms of the surface structure of the text (Rinck, Bower, & Wolf, 1998). While it can be concluded that Euclidean distance is not represented in a spatial situation model, it is also plausible that it can be represented but only utilised where necessary. To test this hypothesis, in a third experiment, a similar method to that used in the previous two was employed. However sentences were periodically interrupted by test probes for object pairs located in the layout. In these probes, participants were asked which object in each pair was located closer to the protagonist. An increase in Euclidean distance led to an increase in response times for relative distance judgments. However, reading times for anaphoric sentences was only affected by manipulations of categorical distance. As such, Rinck et al. conclude that situation models can represent Euclidean distance but are only used when necessary.

A later study by Rinck and Denis (2004) used a map-learning method similar to that of Rinck et al. (1997). However, after memorising a map that contained rooms that were either short or long (i.e. two short rooms with one barrier between them, or one long room of an equivalent size to the short rooms but with no barrier), participants were instructed to imagine moving through the locations that were numbered in a clockwise manner (e.g. ‘You walk from Hall 6 into Hall 8’), instead of reading about the actions of a different protagonist. Accessibility for objects was measured by a probe task in which participants had to respond as quickly as possible whether two objects were located in the same or in different rooms. Importantly, the results showed that as both Euclidean and categorical distance increased participants were slower to respond to probes. While these two factors did not interact, the decrease in reaction time following a shift in space was stronger for categorical than for Euclidean distance: In order to reduce reaction times, the metric distance between the imagined location of the participant and the objects had to be larger if the object was in a different room to the imagined location of the participant. Importantly, the distance effects of both Euclidean and categorical distance were additive, in that if the participant imagined walking from one room to another, accessibility for the object in the initial location was greatly reduced if the imagined location involved walking to the far end of the new location, rather than staying near to the door connected to the initial location. Why then is there a mismatch in how space is represented across the mental imagery and narrative comprehension literature?

One answer can be found in the types of tasks given to participants and the stimuli used in the experiments. Typically, we often take specific perspectives when understanding narratives. In one study by Anderson and Pichert (1978), participants read a narrative about two boys ‘playing hooky’ from school either from the perspective of a burglar or a potential house-buyer. They found that information that wasn’t recalled when using one perspective became accessible when asked to take the other perspective; our situation models are thus view-specific. In the Rinck and Denis (2004) study, participants read instructions using the pronoun ‘You’, whereas in the Rinck et al. (1997) study they read instructions using the pronoun ‘He’. In the first case, readers are more likely to construct a mental simulation of events from a first-person perspective, whereas in the latter case readers are more likely to take a third-person perspective. This interpretation has been evidenced in picture-verification tasks; we are faster in responding to a picture-verification task if the picture matches the perspective taken (Brunyé, Ditman, Mahoney, Augustyn, & Taylor, 2009). This discrepancy in response times is explained in the Spatial Grounding Hypothesis (Beveridge & Pickering, 2013);

when narratives use first person language we are more likely to form a mental simulation of actions and events from the perspective of the protagonist. This mental simulation, according to Beveridge and Pickering, is based on a spatial situation model, but includes perspective taking for particular actions within an event. In using a simulation, we can make more accurate inferences about the direction of actions and spatial relations described. Using a mental simulation could therefore prompt for a first-person representation that more readily maintains an enriched representation of the spatial relations amongst objects in a layout brought about by a simulation of the sensorimotor experiences associated with traversing a layout (e.g. Borghi, Glenberg, & Kaschak, 2004). This representation could also potentially incorporate a simulation of the movement of the protagonist: When simulating movement from one location to another, this simulation should necessarily incorporate the time taken to move to a new location, with the time to access information in the new location reflecting the time taken to traverse the path to the location. This could also explain the discrepancy in results for the task reported by Kosslyn et al. (1978); it is likely that a representation of Euclidean distance only affects accessibility for information within a mental image when we are prompted to form and use a more image-like representation of space that necessitates scanning across the image – the larger the space that needs to be scanned, the longer this will take. Because we are unlikely to change the perspective used during encoding at retrieval (Shelton & McNamara, 2004), the task demands at encoding often influence the granularity of spatial representation formed, and its influences on retrieval. In summary, we are likely to maintain a representation of space in a situation model that incorporates Euclidean distance, similarly to a representation formed in a mental image, but only when task demands invoke such a representation.

1.1.4. Towards a Theory of Event Segmentation

The relative importance of categorical boundaries over Euclidean distance has been replicated in virtual reality experiments exploring the accessibility of objects in memory during spatial shifts without the need for map learning or for a reading paradigm. Radvansky and Copeland (2006) conducted an experiment in which participants played a computer game on a large projector screen. In this, they controlled an avatar around a virtual environment. As the avatar, they picked up objects from a table in one room and were tasked with setting them down on a table in another room before picking up a new object (with this process being repeated several times). In this task, whenever an object was picked up by the avatar it disappeared, thus participants had no external cues about which object was currently being held. Participants were probed with the name of an object, and were asked to respond with a ‘yes’ if the name corresponded to the object they were carrying (associated) or to the object they recently set down (dissociated), whereas they had to respond with a ‘no’ to any other objects. Radvansky and Copeland replicated the results of Glenberg et al. (1987), in that for their first experiment response times were faster for objects that were associated with the avatar when compared to objects that were dissociated from the avatar. Critically, Radvansky and Copeland explored the role of Euclidean and categorical distance in spatial representations and accessibility for objects by keeping the distance travelled equal across conditions, but by giving response probe tasks at different points. In one case, participants were given the response probe immediately after crossing through a doorway (i.e. the shift condition), but in another case these probes were given upon reaching the halfway point of a larger room (i.e. the no shift condition) so that the only difference across conditions was whether a doorway was crossed prior to the probe task or not. (These two conditions are depicted in a 2-D illustration in Figure 1.3.) Again, ‘yes’ responses were given only when the object was the one currently being carried or recently set down. Participants’ responses to these probes were slower and less accurate immediately after crossing through a doorway, in summary, “walking through doorways causes forgetting” (Radvansky & Copeland, 2006, p. 1154). These findings were attributed to a location updating effect; when a spatial shift occurs (e.g. crossing a doorway), this involves crossing an *event boundary*, or a point by which one of the five dimensions identified by the Event Indexing Model (Zwaan et al., 1995) undergo change such as the working event model can no longer accurately be used to predict the unfolding events (Radvansky & Zacks, 2011; Zacks, Speer, Swallow, Braver, & Reynolds, 2007). Due to this change, the participants’ event model must be updated to accommodate the change in location, a consequence of which is reduced accessibility for information from memory that was relevant prior to updating. Because in both cases the object was no longer visible following the movement of the avatar, accessibility for this object was reduced if a spatial shift occurred as the previous event model for the previous location (and the information within it) became backgrounded.

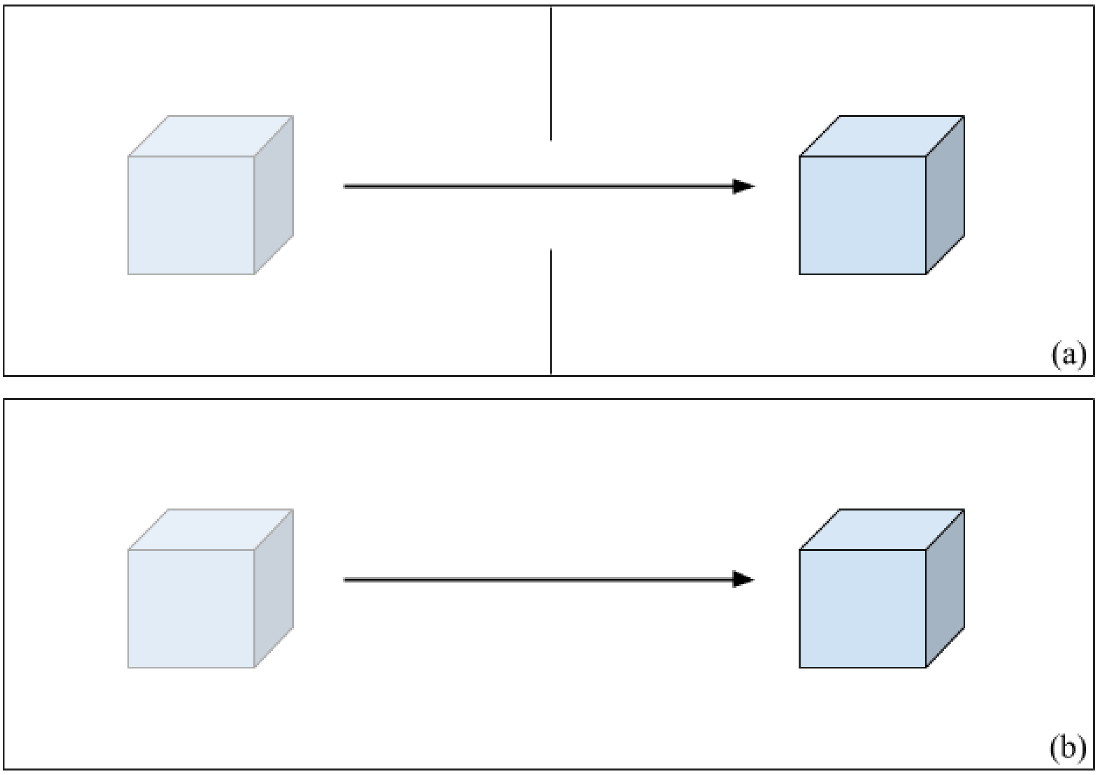

Figure 1.3. An illustrated depiction of the (a) Shift, and (b) No-shift conditions in Radvansky and Copeland (2006). In both cases, response probes were given during the movement of the object (e.g. blue cube) from the initial location (transparent colours) to the final location (solid colours). These probes were given after crossing a doorway in (a) or after reaching the half-way point of the large room in (b)

Further explorations by Radvansky and colleagues have elaborated on the initial findings from the 2006 study. In two experiments, it was found that spatial shifts incurred more response errors and slower response times to probe tasks when probes were both the picture and name of the object that was currently held (or recently set down) (Radvansky, Tamplin, & Krawietz, 2010). Furthermore, when participants were tasked with memorising nonsensical word pairs instead of objects (e.g. *ethnic-cake* instead of *white wedge*), a spatial updating effect was found, with the number of errors in the probe task being greater following a spatial shift. Thus, the type of probe task provided and the integration of information in an environment seemingly has little effect on whether or not a spatial shift can disrupt accessibility for information from memory. A further set of studies explored whether the degree of immersion in an environment could play a role in the previously-reported spatial updating effects. One suggestion was that the more immersed a participant is in their environment the more likely it is that effects of spatial categorisation should occur. For example, in one set of studies by McNamara, Altarriba, Bendele, Johnson, and Clayton (1989), participants who were familiar with the Vanderbilt University campus were selected to take part in a priming task, responding whether or not a named building was in the campus of the University. Crucially, location name targets could be preceded by primes of locations either close to or far from the initial location, with foils being plausible but fictional names for buildings. In this case, no effect of spatial priming occurred, however when foils corresponded to locations from an adjacent campus, a spatial priming effect emerged. Spatial priming occurred when using the plausible but fictional foils when a map of the Vanderbilt campus was learned, but with location names replaced with new, fictional names. These findings were taken to support the conclusion that spatial effects only arise when location information is contextualised; in order for space to influence accessibility for locations the names of the locations must be strongly linked with the spatial representation. When decontextualized, the spatial effect may not appear due to this dissociation.

In order to test whether the results of previous experiments in their series of virtual reality tasks (e. g. Radvansky & Copeland, 2006; Radvansky et al., 2010) was influenced by the degree of immersion, a series of experiments reported in one study (Radvansky, Krawietz, & Tamplin, 2011) manipulated the size of display, using a single computer screen instead of a projector, and by using a real-world task instead of a virtual task. Another factor under consideration was whether the spatial updating effects previously reported were driven by encountering new rooms, or by encoding-specificity (Tulving & Thomson, 1973). When the experiment was carried out and displayed on a computer monitor, more errors were made in responses to probe tasks when a spatial-shift occurred, replicating the results of Radvansky and Copeland (2006). To apply this experiment to a real world setting, trials were condensed so that only three rooms were moved through in both conditions, but six objects were moved each time. In this case, participants initially lifted up an inverted box covering six coloured objects before picking up the objects and placing them back in the box and covering it with a lid. They then walked to the next table and placed the box down before taking part in a recognition test provided by the experimenter on a laptop, asking whether an object was in the box. The recognition probes corresponded to different shape and colour combinations, such that half of the time probes would require a yes or no response. Critically, this test could be conducted halfway through a long room or immediately after walking through a doorway. The results of this experiment supported previous findings, such that more forgetting occurred following a spatial shift to a new location versus walking across one room. Whilst these experiments have shown that the location updating effect is robust and occurs seemingly independently of the degree of environmental immersion, one question remains as to the locus of effects reported; is the spatial updating effect driven primarily by a decrease in accessibility for information following a spatial shift due to the spatial shift itself, or does it reflect encoding-specificity (e.g. Tulving & Thomson, 1973), in which accessibility for objects is decreased because the location at retrieval differs from that at encoding?

One explanation is that the location updating effect is due to a difference in the environmental context at encoding and retrieval, or an example of encoding specificity (e.g. Tulving & Thomson, 1973). Although the object was always associated with both the start and end location across conditions in all experiments, this account could still be plausible, therefore a third experiment was run to test this explanation. If encoding-specificity influences accessibility for objects in the previous experiments then reinstating the previous location should remove any spatial updating effect previously found. Thus, in this experiment, Radvansky et al. (2011) introduced a condition in which the participants returned to the initial location following a spatial shift. Because this return condition constituted two spatial shifts, a further condition was included that also involved two spatial shifts but to new locations. Using a method similar to that used by Radvansky and Copeland (2006), participants controlled an avatar around a virtual environment with the experimental program presented on a large, highly-immersive display. However, for the return and double-shift conditions, instructions were presented half-way through the second room to guide participants to return to the first room or move on to another room. Replicating previous results, it was found that participants were more likely to forget which object was currently held (or recently set down) following a single shift to a new location. However, returning to the initial location did not significantly improve memory for objects. Error rates in the return condition were similar to the single-shift condition but better than the double-shift condition. Furthermore, making a double-shift led to a significant decline in memory for objects when compared to a single shift. Thus, the number of unique locations encountered influences accessibility for objects, not the number of shifts made.

Moreover, the degree of immersion in the environment seemingly has little effect on whether or not a location updating effect occurs. Thus, it might be predicted that unlike in the case of Euclidean distance (cf. Rinck & Denis, 2004; Rinck et al., 1997), shifts in categorical space should have an effect on the accessibility for information regardless of the perspective used during processing. Considering these results in light of language comprehension studies (e.g. Glenberg et al., 1987; Radvansky, 1999; Rinck et al., 1997), it is less plausible that any reported effects are driven by a disruption in visuo-spatial processing; instead, these results likely reflect differences in the event structure across conditions.

Whilst there is strong evidence of spatial updating and segmentation of information into different streams of events, or event models, upon encountering an event boundary, it is unlikely that with space, these boundaries are only represented by doorways between locations (e.g. Radvansky & Copeland, 2006; Radvansky et al., 2011, 2010). As such, recent research has aimed to explore at which points comprehenders naturally identify the point in which one event ends and another begins; the point of event segmentation. Not only has recent research identified when event segmentation occurs and under which circumstances, but it has also highlighted how pervasive the event segmentation process is across a range of research methods. For example, Magliano, Miller, and Zwaan (2001) have shown that whilst passively viewing a film with the task of pressing a button to identify a change in events, participants often identify an event boundary at changes along the same dimensions outlined by the Event Indexing Model (Zwaan et al., 1995), and these changes are identified spontaneously under no instruction for what constitutes the beginning and end of an event. However, by using such button-press tasks, continuous tracking of the ongoing state of affairs becomes more difficult and as such interferes with the processes they aim to measure (Kurby & Zacks, 2008). Thus, by using non-invasive methods of brain imaging, such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG), we can more directly observe the processing costs associated with event shifts whilst not interfering with ongoing processing and tracking of sequences of events.

In one study, participants were tasked with viewing a short video of everyday events with the task to remember as much as possible. Upon re-watching the videos whilst brain activity was recorded using fMRI it was found that increases in brain activity were associated with the presence of an event boundary (Zacks et al., 2001). Indeed, transient changes in brain activity have been found at points within narrative films where spatial, temporal, object, or character features undergo substantial change, with changes along these dimensions being later identified as event boundaries by comprehenders (Zacks, Speer, Swallow, & Maley, 2010). Furthermore, the points in which participants identified event boundaries within narrative text has been found to correspond to increases in brain activity, with the active brain regions upon identifying an event boundary during narrative comprehension corresponding to those identified during passive viewing of videos (Speer, Zacks, & Reynolds, 2007). These brain imaging findings correlate with behavioural measures of increased processing load following an event shift: In one study conducted by Swallow and Zacks (cited by Kurby & Zacks, 2008), participants viewed films whilst their eye-movements were recorded. It was found that during an event segmentation task, pupil diameter increased at points where event boundaries were encountered. Together, these findings support the notion that comprehenders spontaneously track event changes during processing; whether this be when participating in (Magliano, Radvansky, Forsythe, & Copeland, 2014), viewing (Zacks et al., 2001), or reading about changes in events (Speer et al., 2007) even in the absence of an overt task. Crucially, Speer et al. (2007) have found evidence that coarse changes (i.e. the largest participant-defined units of activity within an ongoing sequence of events) in events evoked a larger response than fine-grained (i.e. the smallest participant-defined units of activity within an ongoing sequence of events) changes; that is, when the sequence of events changes substantially rather than minimally, a larger response is elicited. These data provide crucial evidence into the different types of updating that occur during event segmentation and the influences these different types of updating have on accessibility for information. How and when this updating occurs is established in Section 1.1.5, below.

1.1.5. Event Segmentation Theory and the Event Horizon Model

Event Segmentation Theory (EST: e.g. Radvansky & Zacks, 2011; Zacks, Speer, Swallow, Braver, & Reynolds, 2007) proposes that the ongoing stream of events is monitored as a sequence unfolds in order to predict upcoming events; crucially, event models are thought to subserve this process. Event models are thought to maintain an active representation of the perceived or conceived state of affairs in order to bias perceptions and understanding for events (Zacks et al., 2010). Using an event model structure is adaptive as it structures information and facilitates comprehension for future events in light of what has already occurred. Event segmentation is thought to be an adaptive process as it allows for chunking of an extended sequence of events into one unit in order to save on processing and to improve comprehension; holding information in the current event model in working memory, and relegating information from previously-activated event models to long-term memory (Kurby & Zacks, 2008). As such, according to EST the main goal of an event model is to represent what has happened, to integrate it with what is currently happening, and to predict what might happen. Event models are said to bias perceptual processing, allowing comprehenders to disambiguate or expand upon situations. Whilst being relatively robust to missing, ambiguous, or potentially conflicting sources of information, event models must be updated as events change in order to remain relative and helpful for comprehension (Radvansky & Zacks, 2011). Updating is said to occur when event models can no longer be used to accurately predict the ongoing sequence of events, as such the event model must be updated to accommodate this violation of expectations; this updating processing is thought to occur at event boundaries (Radvansky & Zacks, 2011; Radvansky, 2012; Zacks et al., 2007, 2010). In relation to the findings of Speer et al. (2007), updating can occur at both fine and course temporal grains, capturing both small and large changes in events respectively. The granularity or extent of changes in events is crucial for precisely how event models are updated, but is relative to the unfolding sequence of events and is hierarchical in nature (Zacks et al., 2001). For example, a coarse grained event could involve cleaning the house, while fine-grained events could involve plugging in and switching on the vacuum cleaner. In both cases, changes in the events involve updating, with the different types of updating outlined below. But, while changes in events at a fine grain can induce changes in the coarse grained event, this is not always the case; for example, at a fine grained level the event could switch from vacuuming to dusting, requiring updating at the fine grained level, but not at the coarse grained level of ‘cleaning the house’ (Radvansky & Zacks, 2011). It is predicted, however, that similar updating processes act at both granularities of events.

Radvansky and Zacks (2011) argue that there are four ways in which an event model can be updated: model creation, model elaboration, model transformation, and model blending. Largely, due to EST’s focus on the primitives of events – that is, the spatiotemporal makeup of events – changes in space and time are allocated a rather large focus in this theory. Model creation occurs when there is a substantial change in events such that incoming information is unrelated to previous information. An example of model creation is when a protagonist moves from one distinct location to another. This process is thought to be at the heart of the spatial updating effects reported by Radvansky et al. (2011) amongst others. In this case, once the protagonist crosses a doorway from one room to another, the event model for the previous location becomes irrelevant for predicting future events, thus a new model is created to accommodate the events in the new location. This new model becomes the working event model, and the previous event model is backgrounded. It is crucial to note here that current theories of event segmentation assume that only one model can be maintained in working memory at any given time. The result of event creation is that information that was relevant prior to updating becomes less accessible, and information encountered following updating becomes more accessible. Event elaboration involves the inclusion or subtraction of new information into an event that doesn’t substantially change the structure of events. For example, this can be expanding on the colour of a protagonist’s t-shirt, or other minor details that could have been previously elaborated by the comprehender. However, this addition or subtraction of new information cannot influence the functional, temporal, causal or intentional relations of the entities maintained in the event model. In this case, the elaborated information becomes highly accessible, whereas previously encoded information is unaffected. Model transformation involves updating along one or more of these crucial indices, but where the change to these dimensions is not so substantial as to require a new event model. This typically occurs when despite a change along these dimensions the sequence of events is still perceived as ongoing or belonging to the same model. An example of model transformation could be the introduction of a new goal for a protagonist (Radvansky & Zacks, 2011) or perhaps movement of an object within one specific location. Major increases in processing should occur when an event is transformed, with information that was relevant prior to transformation becoming less accessible. Finally, model blending occurs when information maintained in separate event models is perceived to belong to the same event, and as such a new model is created by integrating the information from these two event models. This type of updating occurs when it is initially unclear how two pieces of information relate to one another, but upon encountering some disambiguating piece of information the two models are blended into a single model (Radvansky & Zacks, 2014), as evidenced by studies showing improved memory for layouts when given continuous instructions that allow for integrating the propositions into a single, unified mental model (e.g. Ehrlich & Johnson-Laird, 1982). When two models are blended, information that was previously less accessible should become more accessible when incorporated into one working model. To date, aside from model creation, there is very little research into whether and how each of these types of updating occurs (c.f. Kurby & Zacks, 2012). Yet EST has provided a strong starting-point for explanations of how sequences of events are identified and stored discretely in memory and has inspired an account of how event segmentation influences accessibility for information in working and long-term memory.

The Event Horizon Model (Radvansky et al., 2011; Radvansky & Zacks, 2014; Radvansky, 2012) accounts for how ongoing sequences of events are segmented into discrete event units and encoded into long term memory, and further addresses how event representations are retrieved and the pressures that event structure exerts on accessibility for information maintained within event models. This model uses EST as a mechanism for event segmentation, explaining how we segment ongoing sequences of events into event models. As an explanatory account for event structure, the Event Horizon Model suggests five main principles dictate how the structure of event models influences memory: (a) streams of activity are segmented into discrete event models that are processed one at a time; (b) information in the working event model is most accessible (foregrounded) and maintained in working memory, with backgrounded event models maintained in long-term memory; (c) facilitation of accessibility for information stored across multiple event models during non-competitive retrieval (e.g. accessing as many objects as possible associated with several locations); (d) inhibition of accessibility for information stored across multiple event models during competitive retrieval (e.g. accessing only one representation of an object associated with multiple locations); (e) causal relations between events are stored and can subsequently influence accessibility for information. Together, these principles can be used to explain a range of findings across the event comprehension literature, with a wide range of support for these principles across real-world, virtual-reality and language comprehension studies. As such, the Event Horizon model offers a comprehensive model of modality-independent event representation.

In support of the claims of the Event Horizon Model, there is a wealth of research showing that information in the working event model is most accessible. During language comprehension, response times to probe tasks (Glenberg et al., 1987; Morrow et al., 1987) and reading times (Rinck et al., 1997) often increase when attention is directed to a target object away from the working event model. In comparison, when attention is directed to a target in the working event model, response times and reading times are lower. Similar findings have been reported when viewing a narrative film; viewers are less likely to remember objects that had appeared on-screen five seconds previously if a new event started between the presentation of the object and probe task (Swallow, Zacks, & Abrams, 2009). Furthermore, several studies have shown that when a shift is made to a new spatial location (e.g. walking through a doorway), be this through physical or simulated experience, or even through narrative comprehension, information outside of the working event model becomes less accessible (Radvansky & Copeland, 2006; Radvansky et al., 2011; Rinck et al., 1997). There is also emerging evidence of an increase in accessibility for information distributed across multiple event models during non-competitive retrieval (i.e. when as much information as possible spread across multiple models is to be retrieved, not one piece of information from one particular model); when participants memorise one half of a list in one room and the other half in another, more of the items on the list and more of the structure of the list is remembered when compared to memorising the entire list in one room (Pettijohn, Thompson, Tamplin, Krawietz, & Radvansky, 2016). However, evidence for increased accessibility for information following event segmentation is limited. Still, even in the more widely-explored areas a number of questions remain.

The metric of space maintained in an event model, and the extent to which this metric influences accessibility for information, has been shown to be largely driven by the type of task given to participants (Rinck & Denis, 2004; Rinck et al., 1997); if the type of perspective taken during processing influences whether Euclidean distance or categorical distance influences accessibility for objects from memory, then surely the presentation of that information should also influence the types of event model formed. When using a map-memorisation task, it is possible that a mental representation of space will be heavily influenced by the distinct categorical boundaries represented within the map, possibly subserving a mental representation structured around these categorical boundaries (and neglecting a representation of Euclidean distance). When taking part in physical or virtual-reality tasks, this effect is likely to be further compounded. The question remains, when forming a mental representation of space divorced from distinct categorical boundaries or Euclidean distance, which metric of space is represented? Moreover, can any effects of a spatial shift – either Euclidean or categorical – be divorced from effects of foregrounding? Specifically, are the costs associated with updating an event model present regardless of whether a shift occurs to or from a foregrounded location when the object is only associated with one location during passive listening?

Whilst robust categorical effects have been reported in the literature (Radvansky et al., 2011; Rinck & Denis, 2004; Rinck et al., 1997), it is still not clear whether or not Euclidean distance can be represented and used spontaneously during event processing. Further from this, whilst there is clear support for a decrease in accessibility for information (e.g. an object) following a spatial shift, currently there is little evidence as to why this decrease in accessibility occurs if the object was represented in both the initial and final location. It has been suggested that following a spatial shift, information is represented across multiple event models. In the case of an object crossing through a doorway (Radvansky & Copeland, 2006; Radvansky et al., 2011), the object is thought to be maintained in two distinct event models, with these representations competing with one another at access. However, the majority of studies exploring this issue have used probe tasks, masking the precise mechanism of interference. A decrease in accessibility for an object in this case could plausibly be driven by competition between multiple distinct object instantiations or by an increase in processing associated with maintaining multiple event models (amongst other explanations). Indeed, there is evidence to suggest that the more event models created, the harder it becomes to access information associated with any one model, even when the to-be-accessed information is not associated with all events (Rinck et al., 1997). In order to address the above issues, the present thesis also aims to address the mechanism of interference associated with accessing one instantiation of information associated with multiple event models (i.e. during competitive retrieval). Finally, whilst there is emerging evidence that the association of information with multiple event models is beneficial to access during non-competitive retrieval, there is a distinct lack of support for this claim (but see Pettijohn, Thompson, Tamplin, Krawietz, & Radvansky, 2016).

Together, the present thesis aims to explore: (a) the metric of space represented in an event model in the absence of an overt task; (b) whether foregrounding effects can be isolated from that of spatial shifts; (c) the mechanism of competition during competitive retrieval (e.g. retrieving an object associated with two locations vs. one location); and (d) whether segmenting (otherwise) competitive sources of information into separate models can improve accessibility for a target during non-competitive access for an event model (e.g. observing whether removing a competitor from the same event model as a target reduces competition). In all cases, these experiments aim to establish whether or not the principles of the Event Horizon model hold true for situation models as well as experience models.

1.1.6. Visual Markers of Language Comprehension and Event Updating

A range of studies have shown how event structure influences object accessibility: Probe-response tasks (Morrow et al., 1989) have shown what is being accessed during processing, but not when and how. Whilst analyses of reading time (Rinck et al., 1997) and brain imaging (Speer, Reynolds, Swallow, & Zacks, 2009) have shown that event structure influences online processing, but not why or how. Building upon evidence from Speer et al. (2009) this thesis aims to explore how events are represented with no bias towards the structure of events caused by a particular task (e.g. judging distances). However, in order to fully explore the claims of the Event Horizon model, knowledge of what is being accessed, how it is being accessed, and when it is accessed is crucial. This necessitates a methodological approach with high temporal resolution with clear indices for what is being accessed that can also reflect mechanisms of competition during discourse processing; eye-tracking naturally addresses all of these points, providing a measure of attention and cognitive processing that is time-locked to the occurrence of spoken language (Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). In recent years, eye movements have been used to explore the cognitive processes associated with language comprehension. Using the visual world paradigm (Tanenhaus et al., 1995), a methodology in which visual scenes are presented, often concurrently, with spoken language whilst eye-movements are tracked, several studies have shown that eye-movements towards visual referents reflect what is currently being accessed during language processing. In one study, Tanenhaus et al. explored the automaticity with which grammatical ambiguity can be resolved in the context of ambiguous or unambiguous visual contexts. Broadly, they showed that the visual context in which language is processed can influence where visual attention is allocated during language processing, showing that an initially ambiguous prepositional phrase (e.g. ‘on the towel’ during ‘Put the apple on the towel in the box.’) is more likely to be interpreted as a modifier to the noun in contexts containing more than one apple, and as a prepositional phrase in contexts containing only one apple. Moreover, when using unambiguous language (e.g. ‘Put the apple that is on the towel in the box.’), participants were less likely to attend to the incorrect location (e.g. the empty towel) in the one-apple context. Similar findings have been reported during self-paced reading in studies showing how referential context affects attachment preferences (Altmann & Steedman, 1988). For example, in one study, increased reading times have been found at the disambiguating region and shortly after the disambiguating region (e.g. region +1) within a locally ambiguous sentence (Ferreira & Clifton, 1986). This suggests that eye-movement behaviour in the visual-world reflects linguistic processing in a similar manner to that found in typical linguistic tasks (e.g. reading). In eye-tracking studies involving visual displays, eye-movements are often launched towards potential targets as soon as possible (Allopenna, Magnuson, & Tanenhaus, 1998). Thus eye-movements often reflect what is being accessed during comprehension before participants can act on these instructions, but also reflect when difficulties in processing occur.

Eye-tracking also provides a means by which to establish not only what comprehenders think about when processing language, but what they predict will be uttered next. In one study, Altmann & Kamide (1999) presented participants with a visual scene depicting a boy, a cake, and several non-edible objects (e.g. ball, train-set, toy car). Whilst viewing the visual scene, participants could hear ‘The boy will move the cake’ or ‘The boy will eat the cake’. Here, participants were more likely to fixate on the cake before the onset of the post-verbal noun (i.e. ‘cake’) if the verb could only apply to one object (i.e. in the ‘eat’ condition). These results have been taken to support the notion that not only is language comprehension an incremental process, but both visual and linguistic constraints influence what is both accessed and attended to during comprehension. In a further study, Altmann and Kamide (2009) presented participants with a visual scene depicting a woman, a glass of wine, a table, and several irrelevant distractor objects. Whilst viewing the visual scene, participants could hear ‘The woman *will put* the glass on the table’ or ‘The woman *is too lazy to put* the glass on the table’. Following this, in both cases participants heard ‘…she will pick up the bottle, and pour the wine carefully into the glass’. During the discourse-final ‘the glass’, participants fixated on the linguistically determined location of the glass (either on the floor or on the table) in both conditions. These results are crucial in that they show that fixations on objects located within a visual scene are guided not only by some sort of indexing between the language and visual referent, but by a mental representation of where the object should be within the visual scene. In relation to the Event Horizon Model (Radvansky, 2012), this shows that mental representations of described events can be formed through integrations of visual and linguistic information, and that these mental representations are utilised during language processing. Furthermore, these mental representations are both flexible and updatable. Recent evidence by Kukona, Altmann, and Kamide (2014) has also shown that the previous state of affairs is also maintained following this updating process. In this study, participants viewed a visual scene depicting four containers whilst hearing sentences such as ‘The boy will pour the sweetcorn from the bowl into the jar, and he will pour the gravy from the pan into the jug. And then, he will taste the sweetcorn’. It was found that upon hearing the discourse-final ‘sweetcorn’, participants fixated the final location of the sweetcorn more than all other locations, but that they also fixated on the initial location more so than the two locations that were never associated with the sweetcorn. In keeping with the Event Horizon Model (Radvansky, 2012), these findings show strong support for the notion that whilst a state of affairs can be updated, and these updated representations become highly accessible, previous representations are also maintained.

Together, the reported findings suggest that the visual-world paradigm is suitable for exploring the claims of the Event Horizon model. The visual-world paradigm offers a precise measure of what is being accessed, and when (Allopenna et al., 1998; Altmann & Kamide, 1999). Not only do eye-movements towards linguistic referents reveal the specific time-course of access, but eye-movements naturally reflect competition; comprehenders can only look at one location at a time, so any interference during processing will be reflected in the pattern of eye-movements. This competition is even reflected in cases when a visual scene is no longer depicted on-screen (Altmann, 2004). Moreover, several of the studies reported here used a ‘no-task task’ (e.g. Altmann & Kamide, 1999, 2009; Kukona et al., 2014), allowing for measures of accessibility for referents during relatively naturalistic comprehension. As such, the visual world paradigm offers an accurate measure of object accessibility during language processing, even in the absence of any competing visual information or a potentially biasing task.

1.2. Overview of Experimental Chapters

The literature discussed in this chapter has highlighted a number of outstanding issues in regards to the mental representation of events. Taking the claims laid out by the Event Horizon Model (Radvansky, 2012) it remains to be seen what metric of space is spontaneously constructed during language comprehension and in the absence of an overt task. Experiments 1 and 2 addressed this question: Here, participants were presented with a visual scene depicting a location containing five objects. Participants then either heard sentences describing a protagonist (a) staying in the initial location, (b) moving to a nearby location, or (c) moving to a far-away location either while concurrently (Experiment 1) viewing the visual scene, or shortly after the visual scene was replaced with a blank-screen (Experiment 2). Participants then heard a sentence referencing the protagonist thinking about an object in the initial location, with fixations on the target object during this sentence taken to measure accessibility for the target as a measure of distance travelled by the protagonist from the initial location. Thus, these experiments explored whether spatial representations could be formed and updated during language comprehension, and whether eye-movement behaviours could reveal the metric of space represented; asking, is accessibility for target objects influenced by Euclidean distance or categorical distance? In order to interpret the findings of Experiments 1 and 2, Experiment 3 explored whether the foregrounding effects reported in previous studies (e.g. Glenberg et al., 1987) could be decoupled from spatial updating effects (e.g. Rinck et al., 1997), observing the relative contribution of foregrounding and distance effects on object accessibility. In this experiment, participants viewed a quadrant depicting four objects whilst hearing sentences describing their association with different locations. Participants then heard about a protagonist either staying in one location, or moving from one location to another before thinking about an object in either location. Fixations on the target during this final sentence were taken as a measure of effects of distance and foregrounding on object accessibility.

Experiments 4, 5, and 6 addressed the mechanism of competition at access associated with maintaining multiple representations of objects across the same or different event models. Using blank-screen (Experiment 4) and concurrent paradigms (Experiment 5), participants viewed visual scenes depicting two rooms separated by a doorway. Narratives then described an object moving from one location to another with the doorway either between the path of movement or not. Following Radvansky and Copeland (2006), it was assumed that association of the object with two distinct rooms resulted in segmentation of the two representations of the object (in its initial and final location) into two event models. Whilst this is associated with a decrease in accessibility for the object using probe tasks, these experiments addressed whether this was due to a general increase in processing associated with the maintenance of multiple event models, or by active competition between the two instantiations of the object when associated with multiple events. Upon re-mention of the target object following the movement event, fixations on the initial and final location of the target were taken to observe whether the two instantiations of the object competed more often when associated with two events (i.e. active competition account) or whether accessibility for the final location alone was affected (i.e. general processing disruption). Addressing concerns with the theoretical implications of the results of Experiments 4 and 5, Experiment 6 built upon these two experiments to address whether the reported effects were due to differences in the simulated time-course of events across the two conditions by changing the type of boundary encountered across items. Furthermore, concerns over whether depiction of the object in its initial location could influence visual behaviour were addressed by replacing the two locations with containers, so that only imagined representations were accessed.

Finally, contrary to the majority of results in the event cognition literature (Pettijohn et al., 2016), Experiment 7 explored whether event structure can improve accessibility for a target object under otherwise competitive conditions. In this experiment, participants viewed a quadrant depicting four objects, two of which were semantically related. Whilst viewing the quadrant, participants heard sentences describing the objects as being associated with one location or another, and either together or apart from one another. This experiment addressed whether the effects of foregrounding and distance reported in earlier studies in this thesis could be used to reduce the amount of semantic competition upon re-mention of the target.

In all experiments reported, the specific time-course of these effects was explored in respect to online language processing. Together, these experiments provide answers to the questions outlined above, providing new insights into the mechanics of event representation and the structure of spatial event models.

A summary of the questions explored in the present thesis, and the experiments designed to address these questions is included in Table 1.1.

Table 1.1. A summary of the research questions and series of experiments designed to address these questions in the present thesis

Series of Experiments	Aims	Design
Euclidean vs. Categorical		
Experiment 1 Concurrent visual world paradigm	To explore whether Euclidean distance and/or categorical spatial shifts in a narrative reduce accessibility for a target.	Visual scenes depicted one location and 5 objects. Narratives described a protagonist looking at two objects before staying in the initial location or moving to a new location either nearby or far-away from the initial location before thinking about one of the objects.
Experiment 2 Blank-screen visual world paradigm	See above.	See above. The blank-screen paradigm was used to remove visual-foregrounding.
Shifts vs. Foregrounding		
Experiment 3 Concurrent quadrant display	To explore whether a spatial shift and foregrounding individually contribute to accessibility for a target.	A quadrant displayed four objects. Narratives described a character placing these objects in pairs in two locations before a protagonist was described as staying in one of the locations or moving from one of the locations to another before thinking about one of the objects. This object could be in the same location or a different location to the protagonist.
Instantiation Interference		
Experiment 4 Concurrent visual world paradigm	To explore how interference is manifested when a moved object is associated with the same (Together) or different (Apart) event models.	Participants viewed one of two visual scenes depicting two rooms, containing several objects, separated by a doorway. Narratives described a protagonist moving an object from one location to another, with scenes restricting this movement to be within (Together) the same room or from one room to another (Apart). Narratives described the protagonist looking at a distractor object before picking up the moved object.
Experiment 5 Blank-screen visual world paradigm	See above.	See above. The blank-screen paradigm was used to remove any low-level referential processing for fixations on the source location.

Series of Experiments	Aims	Design
Experiment 6 Concurrent visual world paradigm	To explore whether event segmentation and interference occurs when an object is associated with two rooms separated by a doorway or boundary	See above. Changes included using Doorway and Line-type boundaries in separate items, and changing the source and goal to containers in order to reduce effects of any low-level referential processing.
Semantic Competition		
Experiment 7 Concurrent quadrant display	To explore whether association of a target and semantically-related competitor with the same (Together) or separate (Apart) event models can modulate semantic competition.	Quadrants displayed four objects, two of which were semantically related. Narratives described pairs of objects in one of two locations, with the target and competitor in the same (Together) or separate (Apart) locations, before re-mentioning the target.

Chapter 2

The Metrics of Mental Representations of Space: Euclidean vs. Categorical Distance

2.1. General Introduction

Section 1.1.3 of the present thesis provided a general overview of the metric of space maintained in a spatial event model. Whilst most research in this area has pointed towards a general foregrounding/backgrounding effect, in which objects in one location are more accessible when a protagonist is in that same location, but becomes less accessible once a protagonist leaves (e.g. Glenberg, Meyer, & Lindem, 1987). However, there are several conflicting results for whether 'backgrounded' information becomes less accessible the further the protagonist travels from this initial location. A series of influential studies run by Rinck, Bower, and colleagues (e.g. Morrow, Greenspan, & Bower, 1987; Rinck & Bower, 2000; Rinck & Bower, 1995) used a map learning paradigm to explore whether objects in backgrounded locations became less accessible the further the protagonist travelled from them. Whilst the findings of these studies were initially taken to support the claim that objects become less accessible the further a protagonist is from the initial location in a Euclidean sense, further studies have disconfirmed this claim. Instead, Rinck et al. (1997) showed that it is the number of distinct locations (or rooms) between the protagonist and initial location that matters, not the Euclidean distance between them. Further support from the event model literature supports this claim; when the Euclidean distance travelled remains the same, but an event boundary (e.g. doorway) is introduced between the path of movement, objects become less accessible (Radvansky & Copeland, 2006; Radvansky et al., 2011). As such, it has been concluded that although Euclidean distance can be encoded into an event model, it is only used, and only influences object accessibility if task demands require this metric; when judging distances between objects, for example (Rinck et al., 1997).

When participants are asked to imagine themselves as actively taking part in a sequence of events (Rinck & Denis, 2004), or asked to imagine a picture and mentally scan along it (Kosslyn, Ball, & Reiser, 1978), there are clear effects of Euclidean distance when using recognition probe tasks; generally, the further an object is from a point of reference, the more difficult it becomes to access the object. Thus, there seems to be a clear distinction between the metric of space utilised, and its influence for object accessibility, depending on the type of representation used. While it may be concluded that, in the absence of an overt task, Euclidean distance only influences accessibility for objects when using mental imagery (Rinck & Denis, 2004), another explanation may account for the discrepancy in results across the different types of tasks. That is, this discrepancy may be primarily dependent upon task demands. When using mental imagery, we are likely to create a mental simulation of events using a first person perspective (Beveridge & Pickering, 2013). In doing so, we are likely to simulate the described actions and motions associated with the protagonist. If the distance between a protagonist and an object increases in this case, the object presumably becomes less accessible as the sequence of simulated events is longer and more complex. Indeed, both time and space have been found to be additive (Rinck & Bower, 2000). As such, the time taken to access the target object should decrease. Moreover, if a mental image is formed, we are likely to mentally scan along the image to access an object relative to a reference point; as the distance between the two increases, so does the time taken to access the object (Kosslyn et al., 1978), a claim supported by eye-tracking evidence (Lindsay, Scheepers, & Kamide, 2013). If, however, the narrative uses a third-person pronoun, or a mental image is not relied upon, whilst comprehenders naturally focus upon information relevant to the protagonist, they do not adopt the perspective of the protagonist (O'Brien & Albrecht, 1992). In doing so, it is likely that mental representations are formed around event units (Rinck et al., 1998), or individual event models separated at event boundaries (Radvansky & Zacks, 2011) and that these models are represented in at least a partially-hierarchical structure (e.g. McNamara, 1986), with categorical distance a stronger cue for location-based regional membership of both the protagonist and objects.

Task demands could also be implicated in the metric of space relied upon during narrative comprehension tasks. As McNamara (1986) has shown, while categorical distance provides a strong cue for the location of objects – incorporated into the spatial representation of those objects – Euclidean spatial-relations are maintained and affect accessibility for objects. As noted by Rinck et al. (1997) the majority of research exploring the effect of distance on object accessibility has confounded Euclidean distance with categorical distance (e.g. Morrow, Bower, & Greenspan, 1989; Rinck & Bower, 1995), and very little research to date has directly assessed which metric influences object accessibility during narrative comprehension (e.g. Rinck et al., 1998; Rinck & Bower, 2000). Whilst findings have shown support for effects of categorical and not Euclidean distance when reading third-person narratives, most research to date has used a map-learning paradigm similar to that of Morrow et al. (1987). In doing so, spatial regions are clearly defined by distinct boundaries between locations. Similarly, with virtual reality (Radvansky & Copeland, 2006) and real-world tasks (Radvansky et al., 2011), the walls and doorways between locations are clearly highly salient boundaries for segmenting space into categorical regions, providing strong cues by which to segment events into separate event models. As such, when taking part in such tasks, a spatial representation is likely to be structured around and reliant upon these salient cues.

All experiments to date in this area have either used probe tasks (e.g. Rinck & Bower, 2000) or reading-time (e.g. Rinck et al., 1998) as a measure of object accessibility. Whilst probe tasks can tell us what is being accessed, they do not tell us precisely when it is being accessed. Furthermore, whilst reading time gives a gross measure of when spatial updating effects occur, i.e. within a given point in a sentence, they do not tell us what drives this reduction in accessibility. Evidence by de Vega (1995) has shown that spatial updating only influences object accessibility if reference is made back to an integrating piece of information, for example, using anaphoric reference for the target object following a spatial shift. However, by using probe-response tasks, this paradigm was not especially sensitive to the time-course of spatial event model updating. Yet, in-keeping with evidence from Rinck et al. (1997) who found that the type of task provided to measure accessibility also has an influence on the metric of space utilised, Zwaan and van Oostendorp (1993) explored the role of task on the construction and use of spatial event models. In this study, participants were provided with a relatively complex narrative under the instructions of reading the text normally or reading with a focus on spatial information. Participants read the discourse more quickly if given the natural reading instruction set rather than the spatial focus instruction set. Moreover, when instructed to read with a focus on space, comprehenders formed relatively rich spatial representations – however at a cost to reading times. Given no task, then, it is likely that readers often do not spontaneously track spatial information or form a detailed spatial event model. Thus, there is evidence to the contrary of that suggested by Radvansky and Zacks (2011), suggesting that we do not spontaneously track and update spatial event models during active experience and/or comprehension. Thus, a paradigm which allows for naturalistic narrative comprehension (i.e. with no overt task) which gives a measure of what is being accessed and precisely when, is required. To explore these factors the current experiment uses the visual-world paradigm (Cooper, 1974; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). This approach is critical for the current study as it allows for eye movements, a measure of attention and cognitive processing, to be time-locked to the occurrence of spoken language (Tanenhaus et al., 1995). By using objects within a visual scene to represent linguistic referents this allows for a direct measure of the accessibility of referents during event model processing. Because event models can arise from linguistic and non-linguistic cues (van Dijk & Kintsch, 1983), it is likely that the visual depictions of scenes and the objects within them will be interpreted as part of the described situation, enabling a direct measure of attention and accessibility for objects (in terms of proportion of fixations) without the need for an overt task. By using this method, the current experiment will address three main issues:

(1) Whether comprehenders build a spatial event model without the requirement for explicit instruction to do so.
(2) The time-course with which (any) spatial event models influence accessibility for target objects.
(3) The metric of space represented in spatial event model that influences object accessibility in absence of an overt task (i.e. Euclidean distance (i.e. gradient) vs. categorical).

To explore these issues, in Experiments 1 and 2, participants took part in an eye-tracking experiment using the visual world paradigm and a look and listen task. Participants viewed a visual scene depicting several objects (e.g. Figure 2.1) for a short preview.

Figure 2.1. Example visual scene accompanying spoken sentences, e.g. Example 2.1, in Experiment 1

Following this, participants listened to a narrative discourse (e.g. Example 2.1) describing a protagonist looking towards two of the objects (1) before taking part in an action either in the Same (visually-depicted) (2a) location or in a new location either Near (2b) or Far (2c) from the initial location. The narrative then described the protagonist thinking about one of the two previously mentioned objects (3).

Example 2.1. An example of the linguistic stimuli used in Experiment 1

(1) The boy gazes at the picture and the chair in the room.

(2a) An hour later, he sings in the room.

(2b) An hour later, he sings in the kitchen.

(2c) An hour later, he sings in the playground.

(3) And thinks about how the picture is very beautiful.

The experimental conditions pertained to whether the protagonist stayed within the source location (2a), near the source location (2b), or far from the source location (2c). While the protagonist (boy) remains in the initial location in (2a), he moves to a near location in (2b), and a far location in (2c). Here the terms ‘event model’ and ‘event boundary' are used similarly to previous studies (Radvansky et al., 2011): an 'event model' consists of a series of actions and states (gazing at the picture, gazing at the chair etc) contained within one location. These actions/states are considered to be in one event model unless there is an 'event boundary' (e.g., doorway) between them. In the above examples, it is assumed that there is only one event model in (2a), whereas there are two event models in (2b) and (2c), due to the event boundary between the original and new locations. All items depicted the initial location mentioned in (1) and contained a target (e.g. picture) and competitor (e.g. chair), which were also mentioned in (1). These scenes also contained three other (unmentioned) inanimate objects to serve as distractors (e.g. cactus, television, and window). Following a shift to a new location (2b/2c) or not (2a), the target was then mentioned again in (3). The order of mention of the target and competitor was counterbalanced in (1) across all experimental items so that the target items in (3) could correspond to either the first or second mentioned object in (1). Visual scenes did not depict the protagonist in order to allow for event models to be updated reflecting the location of the protagonist without any conflicting visual information.

Upon re-mention of the target object, fixations on the target object were compared at various intervals time-locked to the specific onset and offset of spoken words in the narrative. Thus, this method provides an accurate measure of accessibility for the target object during online language comprehension and without the need for a task. As for the metric of space that influences object accessibility, both the Euclidean and categorical accounts predict more fixations on the target if the protagonist stays in the initial location (vs. moves to a new location). However, if the Euclidean distance between the protagonist and target influences accessibility for the target, then a larger proportion of fixations should be allocated on the target in the Near condition than the Far condition. If, however, categorical distance alone influences object accessibility, there should be no difference in the proportion of fixations on the target in the Near and Far conditions.

2.2. Experiment 1

2.2.1. Method

2.2.1.1. Participants

Fifty-four (13 male) native speakers of English from the University of Dundee community (aged 17-39, M = 20.80, SD= 4.49) took part in this study for course credit or for £5. All participants had uncorrected vision, wore soft contact lenses, or wore spectacles, and had no known auditory, visual, or language disorders.

2.2.1.2. Apparatus

All sentences were recorded by a male native speaker of British English sampled at 44100 Hz using a Sennheiser SC-60 USB-headset and the Audacity audio suite (Audacity Team, 2014). The prosody of each utterance was normal, yet clear enunciation and pauses in speech were included to allow for ease of comprehension (e.g. Altmann, 2004). Any noise was filtered from speech audio files using the Audacity audio suite, and all audio files were spliced using the Praat software package (Boersma & Weenink, 2016). All visual scenes were created using the GIMP 2.8.4 image manipulation program (GIMP Development Team, 1995), using object images from commercially available ClipArt packages using a 256-colour palette, and consisted of an 800 × 600 pixel image, centred within a grey background of 1024 × 768 pixels.

The experimental program was designed in Experiment Builder, developed by SR Research Ltd. (2013: Ontario, Canada). An SR Research EyeLink-II head-mounted eye tracker with a monocular sampling rate of 500Hz, a spatial resolution of 0.01°, and an average accuracy of <.05° was used, tracking the pupil only. Visual scenes were presented on a 22 inch viewing monitor with a resolution of 1024 × 768 pixels running at 120Hz refresh rate. Participants sat approximately 24 inches away from the display and speakers. Nine-point calibration and validation was used at the start of the experiment and was repeated every 9th item. The pupil was tracked at a sampling rate of 500 Hz from the eye with the most accurate track as determined during calibration and validation; viewing was binocular.

2.2.1.3. Materials

Thirty-six experimental pictures (see Figure 2.1) were paired with spoken discourses consisting of three sentences (1-3). There were three sentential conditions (2a-2c) that correspond to the three manipulations of sentence (2) presented in Example 2.1. Three variations of the length of time between (1) and (2) were introduced at the beginning of (2) across 36 experimental item sets; ‘Minutes later’, ‘An hour later’, and ‘A day later’ in order to control for any mismatch in the perceived time-course of events as a measure of distance travelled by the protagonist (Rinck & Bower, 2000; Zwaan & Radvansky, 1998). Distance manipulations were rotated across three fixed-random lists, with all items using one of the three time-course manipulations across conditions.

A further 36 trials were added as fillers, each containing similar sentence/scene pairs as the experimental stimuli. All filler items mentioned two objects that were present in the visual scene in (1), however in (3) half of the trials referred to a third object that was present within the scene but previously unmentioned, and half of the trials referred to a third object that was neither in the scene, nor mentioned in (1) or (2). Three fixed-random lists of the experimental and filler stimuli were created. Each list contained one version of the three sentential conditions corresponding to each of the 36 experimental items, as well as the thirty-six filler items. Four practice trials were included at the beginning of the experiment, and consisted of two experimental-type items and two filler-type items. For a full list of the sentential stimuli used for recorded sentences, see Appendix A.1. For examples of all visual scenes, see Appendix A.2.

2.2.1.4. Norming Questionnaire

A separate cohort of forty-eight native English speakers took part in a norming study for course credit to test whether experimenter judgments of conditions were confirmed, testing whether participants believe whether the locations used in each item were the same as the initial location in (2a), near the initial location in (2b), and far from the initial location in (2c). Plausibility ratings for the actions described by the protagonist were also taken, testing whether the actions carried out by the protagonist in (3) were perceived to be equally plausible across all conditions.

Three lists of questionnaires were developed, rotating across the three conditions used per item in the eye-tracking experiment. Questionnaires were split into two parts, one for distance ratings, and one for plausibility ratings; all questionnaires were administered and completed online. Participants were presented with an example of how to complete the questionnaire before being given thirty-six questions related to the thirty-six experimental sentences used in the eye-tracking experiment (see Example 1). In the first part of the questionnaire, participants indicated how far away they thought the two locations (e.g. Room and Kitchen) were from each other on a seven-point Likert scale (1 being the same location, 7 being very far away). In the second part of the questionnaire, participants indicated how plausible it was that the events described in the final sentence could happen (1 being not at all plausible, 7 being very plausible). Similarly to the eye-tracking experiment, participants saw one of three lists; rating one condition per item only.

Two one-way repeated measures ANOVAs showed a significant main effect of condition on the distance ratings given to each location in comparison to the initial location: by both participants [$F_1(2, 94)=190.10$, $p<.001$] and items [$F_2(2, 70)=182.70$, $p<.001$]. Post-hoc comparisons using Holm's sequential Bonferroni corrections revealed that the Near condition (*M*=2.97, *SD* =1.39) was rated as being significantly further from the initial location than the Same condition (*M* =1.29, *SD* =0.94), [$p_1<.001$, $p_2<.001$]; that the Far condition (*M* =4.71, *SD* =1.75) was rated as being significantly further from the initial location than the Same condition, [$p_1<.001$, $p_2<.001$]; and that the Far condition was rated as being significantly further from the initial location than Near condition, [$p_1<.001$, $p_2<.001$].

Two one-way repeated measures ANOVAs showed a significant main effect of condition on the plausibility of the actions carried out by the protagonist in (3) by both participants [$F_1(2, 94)=24.51$, $p<.001$] and items [$F_2(2, 70)=23.63$, $p<.001$]. Post-hoc comparisons using Holm's sequential Bonferroni corrections revealed that the actions carried out by the protagonist were rated as more plausible in the Same condition (*M*=4.50, *SD*=1.94) than the Near condition (*M*=4.00, *SD*=1.94), [$p_1<.001$, $p_2<.001$]; in the Same condition than the Far condition (*M*=3.69, *SD*=1.87), [$p_1<.001$, $p_2<.001$]; and in the Near condition than the Far condition, [$p_1<.005$, $p_2=.015$].

From this norming study, it can be inferred that the locations selected for each condition for the items in our eye-tracking study are perceived as being (a) the same, (b) near, and (c) far from the initial location, thus adhering to the experimental manipulations in which they were designed. Further, we can conclude that the plausibility of the events described in (3) decreases the further the protagonist is from the initial location. The results of the norming questionnaire will be discussed later in relation to the eye-tracking findings in the General Discussion (Section 2.4) of Experiments 1 and 2.

2.2.1.5. Procedure

Participants were instructed to look at visual scenes as they appear on the screen and to listen to spoken narratives played over speakers. A look and listen task was selected to avoid any unnatural processing strategies during the task (Altmann, 2004). Each visual scene remained on-screen for the duration of the trial (average of 16,240ms) so that the visual scenes and auditory stimuli were presented concurrently. Participants completed four practice trials at the beginning of the experiment, after which they had the opportunity to ask any questions prior to the continuation of testing. Following the practice section, participants were given the opportunity to ask the experimenter any questions before starting the experiment. The experimental session consisted of thirty-six experimental and thirty-six filler items as outlined in Section 2.2.1.3. For all trials, each scene was displayed for a preview of 1000ms and remained on-screen for the duration of the trial (average of 16,240ms). After the 1000ms preview of the visual scene, the first sentence played. The second sentence played 1000ms after the offset of the first sentence. 500ms after the offset of the second sentence, the third (critical) sentence was played. Each individual trial was automatically terminated 4000ms after the offset of the final sentence. The average durations, onsets, and offsets for each region are presented in Table 2.1. The full testing session lasted approximately 30 minutes.

2.2.2. Results

The proportion of fixations on the target (picture) and competitor (chair) are reported during the onset and offset of the critical region between conditions; Room (Same)/Kitchen (Near)/Playground (Far) locations. The time-course of this region was determined on a trial-by-trial basis (see Table 2.1 for mean durations). In a similar approach to Altmann and Kamide (1999), the proportion of fixations on the target was calculated starting from the onset of the first saccade towards the target, however this time-window was restricted beginning 200ms after the onset of the critical region (i.e. 'picture') until the offset of the critical region within this (hand drawn) region of interest.

In all analyses, selection of the analysis window was determined by the earliest point at which eye movement behaviour was driven by the linguistic stimuli (Barr, 2008). In order to accommodate the time taken to launch a saccade, this window is typically 200ms after the onset of a word (Matin, Shao, & Boff, 1993), such that analyses reflect eye movements as a consequence of the online processing of the linguistic stimuli. In cases where the time-window is restricted to 200ms after the onset of the word, the region for analysis is shifted to include all fixations between 200ms after the onset of the word and 200ms after the offset of the word; in effect, the entire time-window is shifted to the right. Similar concessions were made when the time-window was restricted at different time-points, extending the time window at the offset by the same amount in which it was reduced at the onset. The decision to extend the region of analysis until 200ms after the offset of the word (or later) was made to ensure that restricting the onset of the analysis did not greatly reduce the amount of data included in the analysis. However, as shown by Altmann (2011), language-mediated eye movements can occur as early as 80-100ms after the onset of a word. In some cases, it is possible that participants could anticipate potential referents before mention of a target (e.g. at the determiner). As such, when the observed proportion of fixations on a particular region of interest is shown to increase before 200ms (i.e. at or before the onset of a word), the time window is locked to the earliest point in which a change in fixation proportion is detected. By doing so, the analysis will capture the earliest point of language-mediated eye movements, while avoiding fitting asymptotes, or 'flat' fixation proportion, which are poorly represented in the polynomial functions used in all analyses reported here (Mirman, 2014). This approach thus avoids overfitting models to accommodate the shape of the curve prior to any change driven by linguistic stimuli. In the present experiment, for the proportion of fixations on the target, the time window for analysis was determined as 200ms after the onset of the critical noun as this was identified as the earliest point at which language-mediated eye-movements might occur. Given that all experiments reported in the present thesis are not concerned with the precise timing of eye-movement behaviour (as in the case of prediction (e.g. Altmann & Kamide, 1999), or cohort effects (e.g. Allopenna, Magnuson, & Tanenhaus, 1998) this concession for reducing the time-window for analysis in order to improve model fits is not expected to have any strong bearing on the interpretations of the results in light of the research questions and theory throughout this thesis. Eye-movements launched before a given time-window were included in this analysis and all others in order to avoid bias in the direction of anticipatory baseline effects associated with removing on-target fixations launched prior to the start of the time window (Barr, Gann, & Pierce, 2011). Empirical logit analyses (see Barr, 2008) were carried out for both regions for all analyses in the present thesis. The average proportion of fixations on the target across conditions is included in Figure 2.2.

2.2.2.1. Preparing the Data: The Empirical Logit Transformation

Analyses were conducted using hierarchical mixed-effects models (e.g. Baayen, Davidson, & Bates, 2008) with an empirical logit transformation (henceforth ‘empirical logit’) (e.g. Barr, 2008). This approach was used primarily to account for changes in fixations on interest areas over time, giving a more sensitive and accurate measure for changes in eye movements with a higher temporal resolution and power when compared to traditional methods such as analysing individual time bins (or vertical slices of data) using t-tests or ANOVAs (Mirman, 2014): Gradual changes in data are often difficult to detect using a t-test or ANOVA approach. In order to observe a change in the fixations over time within a time window, data must be segmented into many time bins, but this often results in each bin containing very little data, with subsequent analyses being underpowered. Conversely, to increase power, time bins could be larger but this would result in low temporal resolution, and an inability to detect gradual change throughout the time window. To account for this trade-off, it is often necessary to use the observed data to identify which time bins to analyse, and how large each bin should be; this can inevitably introduce experimenter bias (Mirman, 2014). Instead, by using a hierarchical mixed-effects model, it is possible to include time as a continuous (rather than discrete) variable, allowing for detection of small changes over time while avoiding the above issues. Hierarchical mixed-effects models also allow for modelling data on a non-linear scale, capturing trends in data that may not be captured using traditional methods, also accounting for within-participant and within-item variability in fixations behaviours.

In order to analyse fixation proportion data, a logistic analysis is required as outcomes are bounded to between 1 (fixation) or 0 (no fixation), which linear analyses do not account for. When using a linear analysis, this can then lead to uninterpretable results (e.g. fixation accuracies of greater than 1). Furthermore, for proportion data, variation is not homogenous over the entire range of possible outcomes, with variance larger towards the middle (0.5) than the endpoints (1 or 0) (Mirman, 2014); logistic models account for these issues. When conducting a logistic regression, the logit or log odds transformation is used, where *Y* is the number of 'successes' (or fixations), and *N* is the number of trials (or counts) within each bin, as depicted in Example 2.2, below (adapted from Mirman, 2014):

Example 2.2. Calculating the logit transformation

$$logit(Y, N) = \log\left(\frac{Y}{N - Y}\right)$$

The logistic regression includes the number of trials that produces the proportional data (e.g. whether a proportion of .90 is a result of 9 out of 10 or 90 out of 100 trials). Because experiments often have a small number of trials or a small number of fixations within each time bin, this results in some granularity in the proportion of fixations. Combined with the smaller range of variance towards endpoints, any observed variance towards the endpoints can have a large influence on the outcome of models using a logistic scale (Mirman, 2014). Moreover, when the number of successes matches the number of trials, or when the number of fixations matches the number of counts within a time bin (i.e. when $Y = N$), the function is undefined as dividing by 0 is impossible, resulting in negative or positive infinity values where the proportion of fixations are 0 or 1 respectively (Jaeger, 2008). A solution to these problems is to use the empirical logit transformation (Example 2.3: Adapted from Mirman, 2014); using a logistic scale with a 0.5 adjustment factor to avoid problems associated with perfect scores (hence, named 'empirical' due to the adjustment factor). Crucially, this adjustment scales with the number of observations such that the empirical logit more closely resembles the logit function as more observations are included, but with very few trials, the steep change at 0 and 1 is mitigated (Mirman, 2014). Similarly to a logistic scale, the empirical logit transformation also accounts for the use of categorical data as an outcome measure (i.e. whether a given location is fixated or not).

Example 2.3. Calculating the empirical logit transformation

$$elogit(Y, N) = \log\left(\frac{Y + 0.5}{N - Y + 0.5}\right)$$

Following Mirman (2014), in order to further improve the fit of the model when using the empirical logit transformation, weights (Example 2.4: Adapted from Mirman, 2014) were then assigned to observations based on the variance of the empirical logit in order to reduce the contribution for data towards endpoints in the model (i.e. to reduce the contribution of 0 and 1 probabilities in fixations):

Example 2.4. Calculating weights for the empirical logit transformation

$$w(Y, N) = \frac{1}{Y + 0.5} + \frac{1}{N - Y + 0.5}$$

The model is improved through weighting observations based on their reliability; values based on few trials or towards 0 or 1 are deemed less reliable and as such have less weight in the model, thus improving the accuracy of inferential tests (Mirman, 2014). In all experiments reported in this thesis, the empirical logit transformation was selected instead of a logistic scale to account for the low fixation probabilities often associated with eye-tracking experiments with several regions of interest, or in experiments that use the blank-screen paradigm (e.g. Altmann, 2004). In such cases the empirical logit transformation is more appropriate as it includes an adjustment factor and weights observations to account for the often-problematic occurrences when probabilities approach zero or one (for a discussion, see Barr, 2008).

Data were prepared and analysed using R version 2.15.0 (R Development Core Team, 2008), using the `lme4` package (version 1.0-5). Eye-movement behaviour was coded such that a fixation within any interest area was registered as a fixation, 1, or not, 0. Data were down-sampled from a 500Hz temporal resolution so that fixations were reported every 10ms. Using a method similar to that described in Barr (2008), the data were prepared by aggregating across 50ms time bins over all trials for a given condition within each participant or item depending on by-participant or by-items analyses; separate participants and items analyses were performed throughout. The data were down-sampled into 50ms time bins in order to account for the non-independence of eye-movements, and thus to maintain the integrity of standard errors for significance testing (Barr, 2008). Throughout this thesis, only effects that are significant by participants and by items and interpreted as reliably significant differences such as to warrant interpretation in light of the experimental hypothesis. While hierarchical mixed-effects models can include crossed random effects (e.g. Baayen et al., 2008), including both participants and items as random effects in one analysis, it is impossible to use such a method using an empirical logit regression in the experiments reported in this thesis (and in experiments with a similar design) given that eye-movement data are aggregated over many trials, and given that each participant only sees one item once and thus is not exposed to all conditions for each individual item. Furthermore, robust standard errors are not available for the empirical logit using crossed random effects, thus separate by-items and by-participants analyses are required (Barr, 2008). Thus, in all experiments in the present thesis the transformed proportion of fixations on each interest area were calculated separately for the by-items and by-participants analyses, aggregating across 50ms time bins containing five 10ms frames for the proportion of fixations using the formula in Example 2.2, where *Y* is the number of fixations within an interest area in each bin, and *N* is the total number of frames within each bin (i.e. the number of participants or items divided by the number of conditions × the number of frames per bin). Following Mirman (2014) weights were included in the analyses, as outlined in Example 2.3.

2.2.2.2. Model Coding and Structure

For the current experiment and all other experiments with one factor, dummy coding was used, in which one condition represents the baseline of the model for the intercept and slope terms. In multifactorial experiments, deviation coding is used in order to obtain main effects and main interactions given that the parameter estimates represent the mean difference in log odds between conditions (Barr, 2008). Deviation coding was selected for multivariate comparisons instead of sum coding to maintain the contrast ranges, and scale of parameter estimates, for interactions between parameters (Mirman, 2014). Models were structured to include fixed effects of condition with random effects of participants and participants × condition for by-participants analyses, or item and item × condition for by-items analyses on the intercept and slope for all time terms, using a maximal converging random effects structure where possible. If models failed to converge using the maximal structure they were simplified by removing the correlation between random slopes and intercepts (see Barr, Levy, Scheepers, & Tily, 2013); but see individual experimental chapters for more details.

Across all experiments, time terms were included using orthogonal linear polynomials or higher-order orthogonal polynomials where appropriate. For the functional form of a given model, selection for time terms was constrained by theoretical and statistical considerations outlined by Mirman (2014). Firstly, the functional form of the model was constrained by the predicted form of the observed data, that is, by the predicted number of inflection points within a given time-window. Typically, the given form of the data should reflect the number of changes in attention. For example, when hearing the name of a target object in a visual scene containing no competitors, we might predict an increase in fixations on the target only, with gaze (primarily) remaining within this region; thus a linear model should suffice. If, however, a competitor was present in the visual scene, such that the target is unspecified at the given time of measurement, or attention should be divided between the target and another object on mention of the target, we might anticipate a switch in gaze between the target and competitor (and even back again) after the onset of the critical noun; thus quadratic or cubic polynomials might fit the observed pattern of data more accurately (Mirman, Dixon, & Magnuson, 2008). Yet, higher-order time-terms were only included where clear inflection points were found in observed data to necessitate their inclusion. The contribution of higher-order time-terms was then assessed using a parameter estimates approach. Following Mirman (2014), in order to avoid co-linearity of time-terms and to ensure the stability of parameter estimates, orthogonal polynomials (instead of natural polynomials) were used throughout when higher order terms were included in the analysis. This has important implications for the interpretation of a given model: for natural polynomials, the intercept term represents the difference between conditions at the *y* intercept, or the start of the given time window, with the slope term corresponding to differences in the rate of increase of fixations on a given location. For orthogonal polynomials, the intercept term represents the average of *y* across the entire time window, instead of the *y* intercept, with the slope term being similar in form to that given for natural polynomials. Orthogonal polynomials were used even when only the linear term was included for consistency of interpretation across analyses and experiments. In terms of the experiments in the present thesis, the intercept term reflects the overall difference in the (transformed) fixations on the target between conditions across the entire time-window. The time terms reflect differences in the slope across conditions: For the linear term this reflects the steepness of the slope in a typical linear term, while for the quadratic term this reflects the steepness of the slope in the U-shaped parabolic curve. In all analyses in this thesis, higher-order time terms beyond the quadratic term were not used. Moreover, when higher-order time terms (i.e. those above the linear term) were included, these were selected purely to improve model fit. Because all experiments in the present thesis are concerned with accessibility for objects throughout the entire time-window (i.e. the intercept term) and as time goes on (i.e. the linear term) on mention for the object, time-terms beyond the linear term have little theoretical and/or cognitive interpretation; as such, interpretation for the model is restricted only to the intercept and linear terms in regards to any factors (and their interactions) included in the model. In all experiments, the main focus of the analyses is the intercept term which is taken to reflect the overall accessibility of an object (or objects) throughout the entire time-window, however the linear term is taken to reflect the rate of access for an object (or objects) as time goes on in the time-window.

Across all experiments, parameter estimates were used in order to obtain inferential statistics. Using this approach, *p*-values are estimated using the normal distribution as an approximation for the degrees of freedom (which are unspecified in hierarchical mixed effects models), using the *t*-value as a z-value. Given a sufficiently large sample of observations, such as those obtained from eye movements, the degrees of freedom for the model converge on the normal distribution (Mirman, 2014) such that although *p*-values may be somewhat anti-conservative, they are not overly so (Barr et al., 2013). One advantage of this method is that only one model needs to be created in order to assess the effects of different conditions in experiments with more than two levels in a factor. By re-levelling the baseline reference value in the model, comparisons can be made for all conditions using only model. To do so, contrasts were carried out using the `glht` function in the `multcomp` library (version 1.4-0), providing outputs including *z*-values, standard errors, and parameter estimates, with *p*-values adjusted for multiple comparisons using the single-step method. Where multiple comparisons are reported using this method, the change in parameter estimates between conditions (β) is reported in relation to the baseline reference value; this being the first condition in each comparison. Where multiple comparisons are not necessary, models are reported with parameter estimates, standard error, *t*-values, and *p*-values (estimated using the normal distribution as an approximation for the degrees of freedom).

2.2.2.3. Looks on the target (picture) 200ms after the onset until 200ms after the offset of the critical noun (‘picture’)

The mean duration of fixations was calculated for each time window. Table 2.1 shows the average onset, offset, and duration for each region, from the beginning of each trial (i.e. including the 1000ms preview of the visual scene), taking into account variability with onsets as a result of the experimental program.

Table 2.1. Mean durations of temporal regions in the experimental sentences (ms) in Experiment 1

Label	Region	Onset	Offset	Duration
Sentence 1	‘The boy gazes at the picture (target) and the chair (competitor) in the room.’	1050	4870	3820
Sentence 2	‘An hour later, he sings in the room/kitchen/playground’	5870	8450	2580
Sentence 3				
conjunction	‘and’	8950	9180	230
verb	‘thinks’	9180	9790	610
prepositional phrase	‘about how’	9790	10260	470
determiner	‘the’	10260	10380	120
critical noun	target (‘picture’)/competitor (‘chair')	10380	10950	570
adjectival phrase	‘is very beautiful’	10950	12240	1290

The transformed data for the average proportion of fixations on the target was analysed 200ms after the onset until 200ms after the offset of the critical region (‘picture’) in sentence 3, with the average proportion of fixations shown in Figure 2.2. Using an approach similar to Altmann and Kamide (2009), in Figure 2.2 and in all other figures in this thesis that present the average proportion of fixations, the data are resynchronised at the points depicted by the broken and shaded vertical lines between words or groups of words to account for variance in the average onsets and offsets of these words across different items; accounting for a “cumulative desynchronization” (Altmann & Kamide, 2009, p. 61) for the onsets, offsets, and durations of word or groups of words across items as time progresses. As such, all plots showing the average proportion of fixations contain several zeroes on the x-axis. As analyses were carried out on a transformation of the proportion of fixations, Figure 2.2 (and its values depicted in Table 2.2) are for illustrative purposes only.

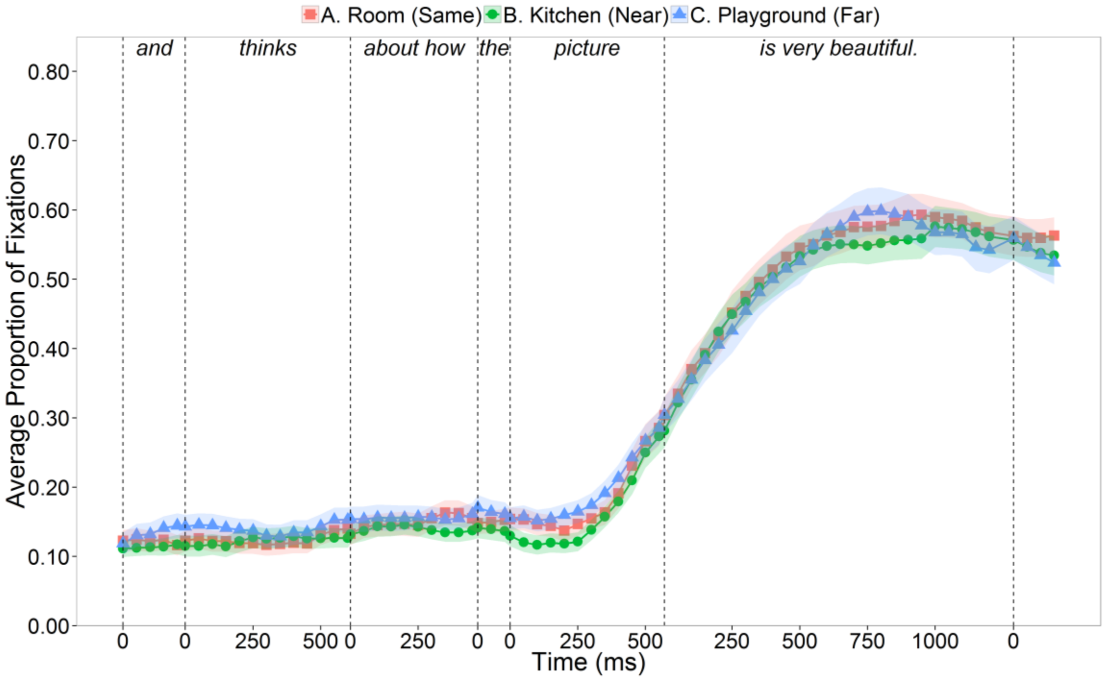

Figure 2.2. Average proportion of fixations on the target (picture) by participants (N=54) as a measure of the protagonist's final location in Experiment 1; shaded bands show standard error

Figure 2.2 shows the average proportion of fixations on the target (picture) by participants across conditions, the values of which are reported 200ms after the onset until 200ms after the offset of the critical noun ('picture') in Table 2.2. The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

Table 2.2. Means and standard deviations for the proportion of fixations on the target (picture) 200ms after the onset until 200ms after the offset of the critical noun ('picture') as a measure of the protagonist's final location in Experiment 1

Condition	*M*	*SD*
Room (Same)	0.242	0.187
Kitchen (Near)	0.232	0.179
Playground (Far)	0.250	0.177

Empirical logit analyses were conducted to analyse the average fixations (log odds scale) on the target (picture) 200ms after the onset until 200ms after the offset of the critical noun ('picture'). Two models were created and run separately for by-participants and by-items analyses respectively, exploring how the final location of the protagonist (Room/Kitchen/Playground) influences fixations on the target over time, with time modelled as a fixed factor using orthogonal linear polynomials. Inspection of the observed transformed data in Figure 2.3 revealed a linear increase in fixations on the target object 200ms after hearing the critical noun, in line with theoretical predictions for the observed data pattern. As such, first-order (linear) orthogonal polynomials were preferred over higher-order orthogonal polynomials in this analysis (Mirman et al., 2008). In all figures depicting model fits in this thesis, zero is set at the onset of the word, but the x-axis is restricted to the region of the analysis, such that in Figure 2.3 the x-axis begins at 200ms which represents 200ms after the onset of the word, or the beginning of the region of analysis (and not 200ms after the beginning of the region of analysis).

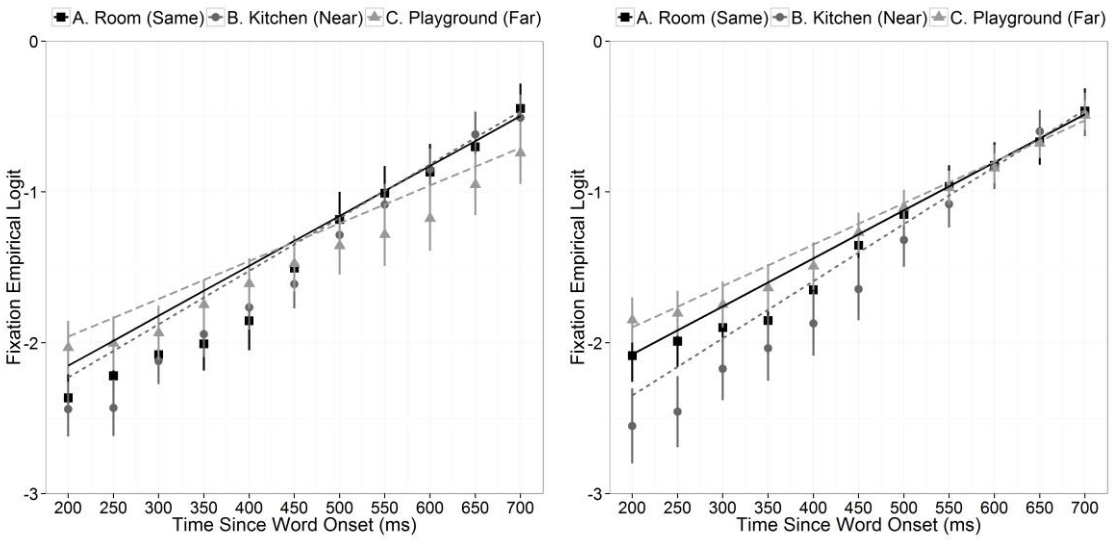

Figure 2.3. Model fits and fixations (transformed data) by participants (Left; N=54) and items (Right; N=36) on the target (picture) 200ms after the onset until 200ms after the offset of the critical noun (‘picture’) as a measure of the protagonist’s final location in Experiment 1; point-ranges represent the empirical logit and their standard errors.

In both by-participants and by-items models, dummy coding was used such that the Room (Same) condition represented the baseline in each model. In order to obtain comparisons for the Kitchen (Near) and Playground (Far) condition, contrasts were performed using the `glht` function from the `multcomp` library (version 1.4-0), adjusting for multiple comparisons using the single-step method. Both models used a maximal converging random effects structure (Barr et al., 2013), with random effects of participants and participants nested within condition on the intercept and slope for the by-participants analysis, and with random effects of item and item nested within condition on the intercept and slope for the by-items analysis. Both models contained fixed effects of the orthogonal linear time term and condition on the intercept and slope. For full model examples, see Appendix B.1. For both models, statistical significance for individual parameter estimates was calculated using the normal approximation.

Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 2.3.

Table 2.3. By-participants [1] (N=54) and by-items [2] (N=36) contrasts of parameter estimates for the transformed fixations on the target (picture) 200ms after the onset until 200ms after the offset of the critical noun region (‘picture’) as a measure of the protagonist’s final location in Experiment 1

Contrast	*β*	*SE*	z-value	Pr(>|z|)
Room vs. Kitchen [1]				
Intercept	-0.023	0.043	-0.528	.979
Linear	0.116	0.062	1.875	.268
Room vs. Kitchen [2]				
Intercept	-0.120	0.031	-3.942	.001**
Linear	0.317	0.061	5.242	<.001***
Room vs. Playground [1]				
Intercept	-0.009	0.043	-0.203	.999
Linear	-0.422	0.062	-6.776	<.001***
Room vs. Playground [2]				
Intercept	0.069	0.030	2.280	.114
Linear	-0.230	0.060	-3.840	.001**
Kitchen vs. Playground [1]				
Intercept	0.014	0.043	0.324	.997
Linear	-0.538	0.062	-8.682	<.001***
Kitchen vs. Playground [2]				
Intercept	0.190	0.031	6.216	<.001***
Linear	-0.547	0.060	-9.064	<.001***

$^{***}p$<.001; $^{**}p$ <.01; $^{*}p$ <.05; $^{+}.1< p<.05$

From Table 2.3, it is clear that there was a non-reliable difference in terms of parameter estimates for the intercept (p_1=.979; p_2=.001) and linear (p_1=.268; p_2<.001) terms for the Room vs. Kitchen comparison. For the Room vs. Playground comparison there was no significant difference between parameter estimates for the intercept term (p_1=.999; p_2=.114), however there was a significant difference between paramter estimates on the linear term (p_1<.001; p_2=.001). Similarly, for the Kitchen vs. Playground comparison there was a non-reliable difference between parameter estimates for the intercept term (p_1=.997; p_2<.001), however there was a significant difference between paramter estimates on the linear term (p_1<.001; p_2<.001). In both comparisons this reflects a slower increase in the proportion of fixations on the target in the Playground condition (vs. the Room and Kitchen conditions). Together, these results suggest that while the target is equally accessible across all conditions across the entire time-window, the rate of access for the target is slower in the Playground condition than the Room and Kitchen conditions.

2.2.3. Discussion

The present study explored how distance is represented in spatial event models during online discourse comprehension in the absence of an overt task, with the aim to determine whether accessibility for objects is influenced by the distance between the protagonist and initial location in a categorical (i.e. room by room) or Euclidean (i.e. metrically) manner. By manipulating the narrative to reflect whether a protagonist made a shift to a new location or not, and manipulating the Euclidean distance travelled by a protagonist if a shift was made, it was possible to differentiate between the two cases. Accessibility for objects was measured as the proportion of fixations on objects in a visual scene. Both accounts predict that looks on the mentioned object would be highest if no movement occurred (i.e. the protagonist stayed in the room) as objects should be foregrounded, and thus highly accessible (e.g. Glenberg et al., 1987). However, whilst the categorical account predicts fewer fixations in the two shift conditions (Kitchen (Near) and Playground (Far)), which do not differ from one another, the Euclidean account predicts fewer fixations in the Playground when compared to the Kitchen condition.

Analyses of transformed proportion of fixations on the target object upon mention revealed no reliable difference across the three conditions throughout the entire time window (i.e. on the intercept). However, as the word unfolded, fixations on the target object increased more rapidly in the Room and Kitchen conditions when compared to the Playground condition; While fixations on the target increased more rapidly in the Kitchen condition when compared to the Room condition in the by-items analysis, there was no difference between the two conditions in the by-participants analysis. Focusing on those findings that are reliable across both analyses, these findings are taken to indicate that there is no difference between conditions in terms of the accessibility for the target throughout the entire time-window. However, the rate of access for the target is slower in the Playground condition when compared to the Room and Kitchen conditions.

These results fail to conform to a range of findings in support of, at least, effects of foregrounding on accessibility for information in working memory (de Vega, 1995; Glenberg et al., 1987; Rapp et al., 2006). While it is possible that given no task participants failed to form and use a situation model during narrative comprehension (Zwaan & van Oostendorp, 1993), as would be reflected in the similar levels of accessibility for the target throughout the entire time-window, given the difference in the rate of increase in fixations as the words unfold between the Room and Playground, and Kitchen and Playground comparisons, it is possible that Euclidean distance could play a role in the rate of accessibility for the target object. When the protagonist is described as being in a location very far away from the initial location (vs. in the initial location or near to the initial location), the rate of increase in fixations on the target object was reduced. Whilst a fully Euclidean account might predict a linear decrease in the rate of fixations as distance increases, here the only difference was between the Room (Same) and Kitchen (Near) vs Playground (Far) conditions. It is possible that the locations used in the Kitchen condition, while rated in the norming questionnaire (Section 2.2.1.4) as being significantly further away from the initial location, were still too close to the initial location to influence the rate of accessibility for the target. Recalling the findings of Rinck and Denis (2004), the metric distance between the imagined location of the participant and the probed-for location had to be larger to observe a Euclidean instead of categorical effect of distance. Again, however, this brings the question of why no effect of categorical distance was found. One interpretation for why the rate of access for the target was lower only in the Playground condition lies in how locations are organised hierarchically in memory: Given a shared superordinate location (i.e. interior/house), it is possible that the Room and Kitchen locations were perceived as belonging to the same event model, such that accessibility for objects in the Room were equally accessible across these two locations. With the Playground being in a distinctly dissimilar superordinate location (i.e. exterior) it is possible that this location was represented in a separate event model and thus information associated with the separate event model of the Room was accessed more slowly. Indeed, recent theories for event segmentation (e.g. Radvansky & Zacks, 2011) propose that event boundaries are not only spatial in nature, but event segmentation occurs at distinct and substantial changes in events; in this case, perhaps a shift to the Kitchen was not deemed to be enough of a substantial change to warrant creation of a new event model?

While the current experiment has shown that the rate of increase in fixations on the target is slower in the Playground condition than the Room and Kitchen conditions over time, it cannot be ignored that no difference between the three conditions was found throughout the time window as a whole. As reading times generally increase (Rinck & Bower, 1995), response times to probe tasks increase (Morrow et al., 1987) as the distance between a protagonist and object increases, it was predicted that any difference in accessibility during language processing would be reflected in difference in the proportion of fixations on the target during the entire time window, and not just on the proportion of fixations as time goes on. Instead, the current results seem to indicate a small effect of space on accessibility during processing, not a robust effect that persists from the point in which a word is recognised until the end of the time-window. One explanation for why a robust effect throughout the general time window was not found lies at the heart of the experimental procedure: in all conditions, participants viewed the visual scene concurrently whilst listening to the spoken narrative. Whilst narratives attempted to manipulate the imagined location of the protagonist, and thus whether the initial location was maintained in the foregrounded working event model, across conditions the initial location was always visually foregrounded. This may have a number of consequences for the processing strategies adopted by participants: (1) the visual foregrounding could act to anchor participants' locus of attention to the Room across conditions; (2) visual depictions of the object could be used as an index for items mentioned in the narrative, reducing working memory load across conditions (Ballard, Hayhoe, Pook, & Rao, 1997); (3) low-level bottom-up referential processing could occur across conditions, in which participants look at the target upon mention with little regard to the narrative (e.g., hearing 'picture' would trigger looks to the picture strongly regardless of the condition). As such, concurrent viewing of the visual stimulus could influence whether a spatial event model is formed or used, and even still, whether or not any real effects of space can be observed in the current dataset. As the current experiment found no effect of any metric of space throughout the entire time window, and unexpected effects for the rate of change in fixations on the target throughout the time window, Experiment 2 aims to address the possible confounds associated with concurrent viewing of the initial location throughout the task.

2.3. Experiment 2

2.3.1. Introduction

In order to address the main concerns associated with concurrently viewing the visual scene whilst hearing the discourse narratives, the present experiment used a variation of the paradigm used in Experiment 1, in which the initial visual scene was removed prior to the onset of the narrative and replaced with a blank screen. This 'blank-screen paradigm' has been used in previous research to explore how we process language and access information from memory whilst relying primarily upon mental representations rather than visual depictions of stimuli (e.g. Altmann, 2004). In a seminal study, Richardson and Spivey (2000) explored whether spatial indices of oculomotor coordinates are used when attempting to recall information that lacks an explicit spatial dimension; semantics. In this series of experiments, participants viewed a 2 × 2 grid whilst viewing and listening to four video clips of talking heads, containing spoken information, one at a time and in a random order. Crucially, after the video clips played, they disappeared from the display, leaving a blank grid. Participants were then prompted with a question, probing for semantic information related to the spoken content from one of the video clips. It was found that participants made significantly more fixations on the blank region of space associated with the presented information relevant to the prompted questions; however accuracy of recall was not improved through looking to the blank regions of space. These results were corroborated by a further experiment that changed the visually distinct videos of talking heads to spinning crosses, thus highlighting that looking behaviour was found to be driven primarily by an association of semantic information with space, and not with any other visual features.

Not only do comprehenders index space for information that was once present, they also index space for imagined information. This has crucial implications for the makeup of a spatial event model; under the assumption that spatial event models integrate linguistic, world knowledge, and perceptual information – reactivating perceptual representations on access (Kosslyn, Thompson, Kim, & Alpert, 1995), Spivey and Geng (2001) explored whether space is indexed and accessed when relying upon a spatial event model even in the absence of any integrating piece of visual information. In this study, participants looked at a white projector screen and listened to narratives intended to create mental imagery about the participant in a given scene, with descriptions taking upward, downward, leftward, rightward, and non-directional spatiotemporal dynamics whilst avoiding explicit directional terms (e.g. 'up', 'left', 'right', etc.). For example, if presented with an audio narrative in the *upward* condition, stories asked participants to imagine themselves outside of a large building, looking up at several floors. The story contained information pertaining to different events at different stories of the building in order to give a sense of the size of the building, and that the imagined perspective was looking up throughout. In the *downward* condition participants were told to imagine themselves at the top of a canyon looking down. Spivey and Geng found that, following spatial descriptions, saccades to the direction indicated by the directional scene description were more likely than saccades to the same direction when given non-directional descriptions. Thus, when imagining events described in a narrative, comprehenders activate similar perceptual-motor mechanisms used when viewing described events (e.g. looking up when then narrative takes this perspective). A further experiment by Spivey and Geng presented participants with a quadrant of four objects. One of the objects was then removed before a question was asked about the object, asking either what the colour or orientation of the object was. They found that participants again tend to look at the blank region of where the object was upon answering questions related to the missing object, but that this effect is stronger when asked about the orientation of the object. Together, these two studies have shown that we tend to look towards where objects were, or are imagined to be, when accessing them from memory – and that spatial information seems to be privileged or at least heavily influences oculomotor behaviour when doing so.

Whilst Spivey and Geng (2001) have shown that when tracking the space of a narrative our eye movements reflect the general directions specified in the narrative, further evidence from Altmann (2004) has shown that our eye movements can be directed to specific locations highlighted by the narrative in the absence of any clear visual cues, and that these eye movements are directed as a consequence of tracking the ongoing narrative or event model. In one experiment, a similar paradigm to that employed by Altmann and Kamide (1999) was used, however prior to the onset of the discourse, the visual scene was replaced by a blank-screen. Similarly to Altmann and Kamide, this study found that participants successfully anticipated the upcoming discourse referent when the pre-referential verb constrained the selection of the target; that is, when viewing a scene depicting a cake and a newspaper, participants made more predictive saccades towards where the cake was prior to the visual scene being removed upon hearing ‘eat’ in ‘the man will eat the cake’. Thus, eye movements are made towards empty regions that were previously associated with the target object in an anticipatory manner, showing that our mental representation of the visual scene guides eye movements. Further support for this notion was provided by Altmann and Kamide (2009) who conducted two experiments exploring how spatial changes influence the allocation of attention during language comprehension. In these experiments, participants viewed a visual scene containing a woman, a wine glass on the floor, a table, and various distractor objects. Participants then heard discourse such as those depicted in Example 2.5:

Example 2.5. An example of the discourse used in Altmann and Kamide (2009)

(i) 'The woman will put the glass on the table.
Then she will pick up the bottle, and pour the wine carefully into the glass.'

(ii) 'The woman is too lazy to put the glass on the table.
Instead, she will pick up the bottle, and pour the wine carefully into the glass.'

In both cases the scene remained unchanged throughout. However, in Experiment 1, participants viewed the scene concurrently whilst hearing the narrative, while in Experiment 2, the scene was removed and replaced with a blank screen prior to the onset of the discourse. In both experiments it was found that participants were more likely to look at the table following 'pour' if the glass was described as being moved to the table (e.g. i) than not (e.g. ii). However, in Experiment 1, in both cases participants were more likely to look at the glass than the table, indicating that whilst spatial representations can be updated, visual representations often 'win out', attracting attention more often than language mediated locations for the target. By replacing the visual scene with a blank screen, and thus removing this competition, Experiment 2 demonstrated that participants were more likely to fixate the table in the moved (i) condition than the unmoved condition (ii), but that crucially, following 'the glass', they are more likely to look at the table than the glass if the glass was described as moving, and more likely to look at the glass than the table if it remained unmoved; showing that in this case, eye movements are guided primarily by mental representations and not visual depictions. Moreover, this experiment provides evidence that we can index space accurately during language processing, and that eye movements can be guided by mental representations of the locations of objects, even when those objects never occupied that space.

The results of these set of experiments are crucial for the current experiment, highlighting that if a visual scene is displayed concurrently during narrative comprehension, and reference is made to an object in the given location, then eye movements are not only driven by the mental representation of the given narrative, but are influenced heavily by the visual scene – with eye movements launched automatically towards a given location when the language disambiguates the target (cf. Altmann & Kamide, 1999; Altmann, 2004). Whereas, when the visual scene is replaced by a blank screen (e.g. Experiment 2 in Altmann & Kamide, 2009) eye movements are directed primarily by the mental representation prompted by the discourse. Thus, the blank screen paradigm provides a promising avenue for exploring the research questions highlighted in Experiment 1 of the current thesis, whilst reducing any confounds associated with the concurrent presentation of a visual scene during narrative comprehension. As such, the present experiment aims to explore which metric of space is utilised during narrative comprehension when accessibility for objects is primarily reliant upon a mental representation of events, not a visual depiction of one described location. Using the same method as Experiment 1, but replacing the visual scene with a blank screen prior to the onset of the discourse, this experiment asks whether accessibility for objects is influenced by either categorical or Euclidean manipulations of space.

2.3.2. Method

2.3.2.1. Participants

Fifty-four (18 male) native English speakers from the University of Dundee (aged 18-29, *M* = 20.76, *SD*= 2.89) took part in this study for partial course credit or for £5. All participants had normal or corrected to normal vision, and had no known auditory, visual, or language disorders. No participants in this study had previously taken part in Experiment 1 of the present thesis.

2.3.2.2. Apparatus

The same apparatus used in Experiment 1 was used here.

2.3.2.3. Materials

The same materials that were used in Experiment 1 were used here. However, one item was excluded from the analysis due to a playback error in this experiment. In total, thirty-five experimental items were used and included in all analyses.

2.3.2.4. Procedure

A similar procedure to Experiment 1 was utilised in that each scene was displayed for a preview of 1000ms and following this, three sentences were played over speakers. However, unlike Experiment 1, each visual scene was replaced by a blank-screen prior to the onset of auditory stimuli. This blank-screen paradigm (Altmann, 2004) was used to avoid any visual foregrounding for the initial location during language processing across conditions (see Zwaan & Radvansky, 1998).

For all trials, each scene was displayed for 7000ms and was then replaced by a blank screen for the remaining duration of the trial (average of 16,260ms). After a 1000ms preview of the blank screen, the first sentence played. The second sentence played 1000ms after the offset of the first sentence. 500ms after the offset of the second sentence, the third (critical) sentence was played. Each individual trial was automatically terminated 4000ms after the offset of the final sentence. The average durations, onsets, and offsets for each region are presented in Table 2.4. The full testing session lasted approximately 45 minutes.

2.3.3. Results & Discussion

The same analysis used in Experiment 1 was used here. However, due to a playback error, one item was excluded from the analysis. For this experiment, critical regions of interest were defined as the locations where the target (picture) and competitor (chair) were prior to the onset of the blank-screen, using the same regions as those in Experiment 1. The proportion of fixations on where the target (picture) and competitor (chair) were located prior to the onset of the blank-screen are reported during the onset and offset of the critical region between conditions; Room (Same)/Kitchen (Near)/Playground (Far) locations. The time-course of this region was determined on a trial-by-trial basis (see Table 2.4 for mean durations). The proportion of fixations on the target was calculated starting from the onset of the first saccade towards the target 200ms after the onset of the critical region (i.e. ‘picture’) (e.g. Altmann & Kamide, 1999), until 200ms after the offset of the critical region within this (hand drawn) region of interest. A similar method was employed for fixations on the target and competitor during an earlier region (‘about how the’), however here fixations were included from the onset of ‘about how’ until the offset of ‘the’, such that analyses reflected eye movements as a consequence of prediction for the upcoming critical referent. Empirical logit analyses (see Barr, 2008) were carried out for both regions, a discussion of which is included in Section 2.2.2.1. Table 2.4 shows the average onset, offset, and duration for each region, taking into account variability with onsets as a result of the experimental program.

Table 2.4. Mean durations of temporal regions in the experimental sentences (ms) in Experiment 2

Label	Region	Onset	Offset	Duration
Sentence 1	‘The boy gazes at the picture (target) and the chair (competitor) in the room.’	8048	11888	3840
Sentence 2	‘An hour later, he sings in the room/kitchen/playground’	12888	15476	2588
Sentence 3				
conjunction	‘and’	15980	16200	220
verb	‘thinks’	16200	16820	620
prepositional phrase	‘about how’	16820	17280	460
determiner	‘the’	17280	17400	120
critical noun	target (‘picture’)/competitor (‘chair')	17400	17950	550
adjectival phrase	‘is very beautiful’	17950	19260	1310

2.3.3.1. Looks on the target (picture) 200ms after the onset until 200ms after the offset of the critical noun ('picture')

Figure 2.4 shows the average proportion of fixations on the target (picture) by participants across conditions.

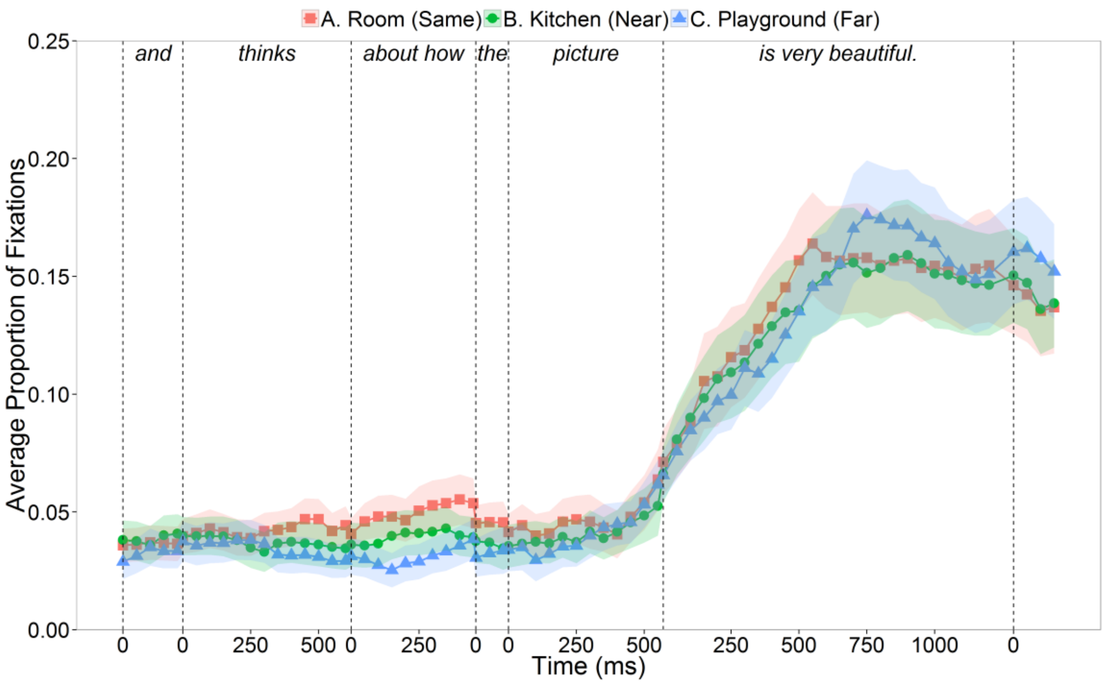

Figure 2.4. Average proportion of fixations on the target (picture) by participants (N=54) as a measure of the protagonist's final location in Experiment 2; shaded bands show standard error

Table 2.5 shows the mean proportion of fixations and *SD* for the analysed region, 200ms after the onset until 200ms after the offset of the critical noun ('picture'). The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

Table 2.5. Means and standard deviations for the proportion of fixations on the target (picture) 200ms after the onset until 200ms after the offset of the critical noun ('picture') as a measure of the protagonist's final location in Experiment 2

Condition	*M*	*SD*
Room (Same)	0.058	0.092
Kitchen (Near)	0.052	0.087
Playground (Far)	0.055	0.078

Similarly to Experiment 1, empirical logit analyses were conducted to analyse the average fixations (log odds scale) on the target (picture) 200ms after the onset until 200ms after the offset of the critical noun ('picture'). Two models were created and run separately for by-participants and by-items analyses respectively, exploring how the final location of the protagonist (Room/Kitchen/Playground) influences fixations on the target over time, with time modelled as a fixed factor using orthogonal linear polynomials. Similarly to Experiment 1, orthogonal linear polynomials were preferred over higher-order orthogonal polynomials as the discourse disambiguated the target object at the onset of this time-window (Mirman et al., 2008). As such, it was predicted that fixations on the target should increase linearly; no objects within the scene are likely to attract attention away from the target object in such a manner as to change the shape of observed data to require modelling with higher-order polynomials.

For by-participants and by-items models, the overall time course of fixations was captured using a first-order (linear) orthogonal polynomial with fixed effects of condition (Room vs. Kitchen, Playground) on the linear term. Both models used a maximal converging random effects structure (Barr et al., 2013), with random effects of participants and participants nested within condition on the linear term for the by-participants analysis, and with random effects of item and item nested within condition on the linear term for by-items analysis. In both by-participants and by-items models, dummy coding was used such that the Room (Same) condition initially represented the baseline in each model. In order to obtain comparisons for the Kitchen (Near) and Playground (Far) condition, contrasts were performed using the `glht` function from the `multcomp` library (version 1.4-0), adjusting for multiple comparisons using the single-step method. For full model examples, see Appendix B.2. For both models, statistical significance for individual parameter estimates was calculated using the normal approximation. Parameter estimates for all contrasts across both types of model are shown in Table 2.6.

Table 2.6. By-participants [1] (N=54) and by-items [2] (N=35) contrasts of parameter estimates for the transformed fixations on the target (picture) 200ms after the onset until 200ms after the offset of the critical noun region (‘picture’) as a measure of the protagonist’s final location in Experiment 2

Contrast	*β*	*SE*	z-value	Pr(>|z|)
Room vs. Kitchen [1]				
Intercept	-0.109	0.110	-0.984	.829
Linear	-0.111	0.181	-0.617	.964
Room vs. Kitchen [2]				
Intercept	-0.160	0.115	-1.396	.560
Linear	0.338	0.159	2.133	.157
Room vs. Playground [1]				
Intercept	-0.012	0.110	-0.105	1.00
Linear	0.153	0.180	0.846	.894
Room vs. Playground [2]				
Intercept	-0.125	0.115	-1.088	.763
Linear	-0.077	0.159	-0.486	.984
Kitchen vs. Playground [1]				
Intercept	0.097	0.110	0.879	.880
Linear	0.264	0.181	1.462	.523
Kitchen vs. Playground [2]				
Intercept	0.035	0.115	0.308	.997
Linear	-0.416	0.160	-2.604	.049*

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

From Table 2.6, it is apparent that in all comparisons there was no reliable difference between the parameter estimates on the intercept and slope terms (all *p*s >.05 (excluding the Kitchen vs. Playground comparison on the linear term by items; p=.049). This indicates that there is no difference between conditions in the proportion of fixations on the target (picture) either throughout the entire time-window or as time goes on during the critical noun region (‘picture’). However, upon closer inspection of Figure 2.4, it appeared that the three conditions tended to be numerically different in a previous, anticipatory region. It is possible that during this region participants recognised that – at least in the experimental items – the critical target in the final sentence was equally likely to be one the two objects mentioned in the first sentence. Thus, eye-movements were compared during an anticipatory window that spanned the verb offset to the noun onset (‘about how the’) to observe any differences in the transformed fixations on the potential targets across conditions.

2.3.3.2. Looks on the target (picture) and competitor (chair) during the anticipatory region (‘about how the’)

An empirical logit analysis similar to that used in Experiment 1 was conducted on a region prior to the onset of the critical noun (i.e. the anticipatory region, ‘about how the': see Table 2.4). Here, fixations were counted from the onset until the offset of the anticipatory region ('about how the'), and not 200ms after the onset or 200ms after the offset as, naturally, this constitutes an anticipatory region, and as such the time to process the incoming discourse was not deemed a necessary factor to include in analyses, removing the need to exclude any data. Because participants must anticipate the referent during this region, analyses include looks to both the target (picture) and competitor (chair) as these were the two objects that were mentioned in the first sentence of the discourse; one of which would be mentioned again half of the time in the final sentence amongst experimental items in an attempt to reduce anticipation for the target. The average proportion of fixations on both of these interest areas across conditions by participants is displayed in Figure 2.5, with means and *SD* also reported in Table 2.7. The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

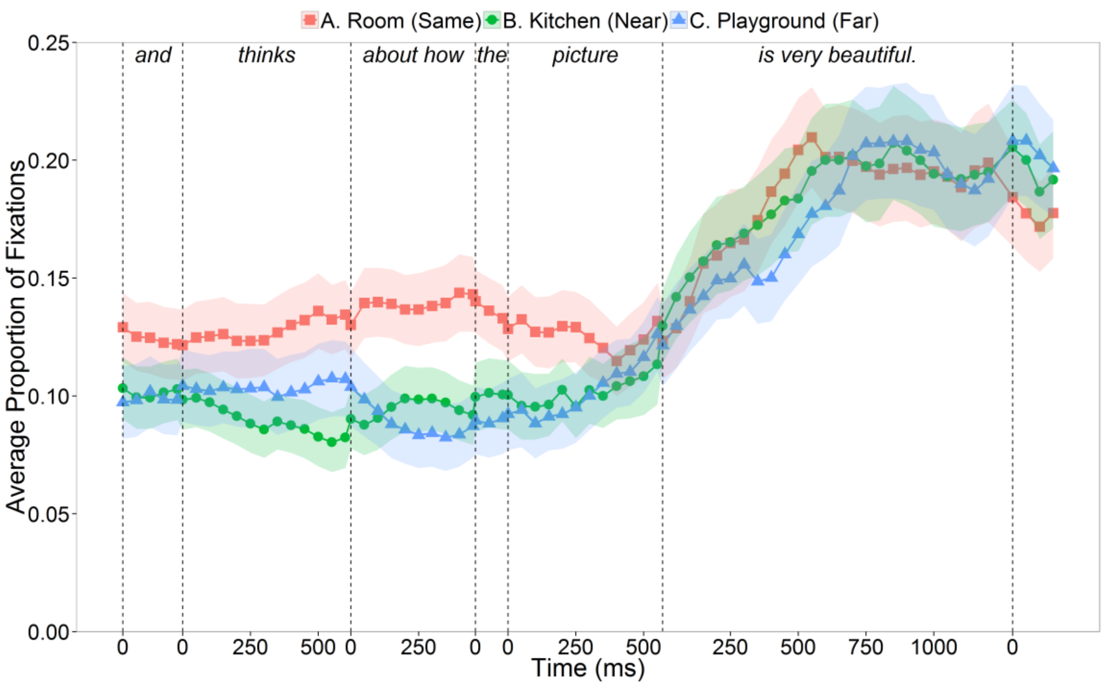

Figure 2.5. Average proportion of fixations on the target (picture) and competitor (chair) by participants (N=54) as a measure of the protagonist's final location in Experiment 2

The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

Table 2.7. Means and standard deviations for the proportion of fixations on the target (picture) and competitor (chair) during the anticipatory region ('about how the') as a measure of the protagonist's final location in Experiment 2

Condition	*M*	*SD*
Room (Same)	0.138	0.110
Kitchen (Near)	0.094	0.095
Playground (Far)	0.089	0.105

Again, two models were created and run separately for by-participants and by-items analyses respectively, exploring how the final location of the protagonist (Room/Kitchen/Playground) influences fixations on the target and competitor over time, with time modelled as a fixed factor using orthogonal polynomials. Here, one inflection point was observed for the shape of the curves across conditions for the transformed data (Figure 2.6). As such, first (linear) and second-order (quadratic) orthogonal polynomials were included as time-terms in the analysis.

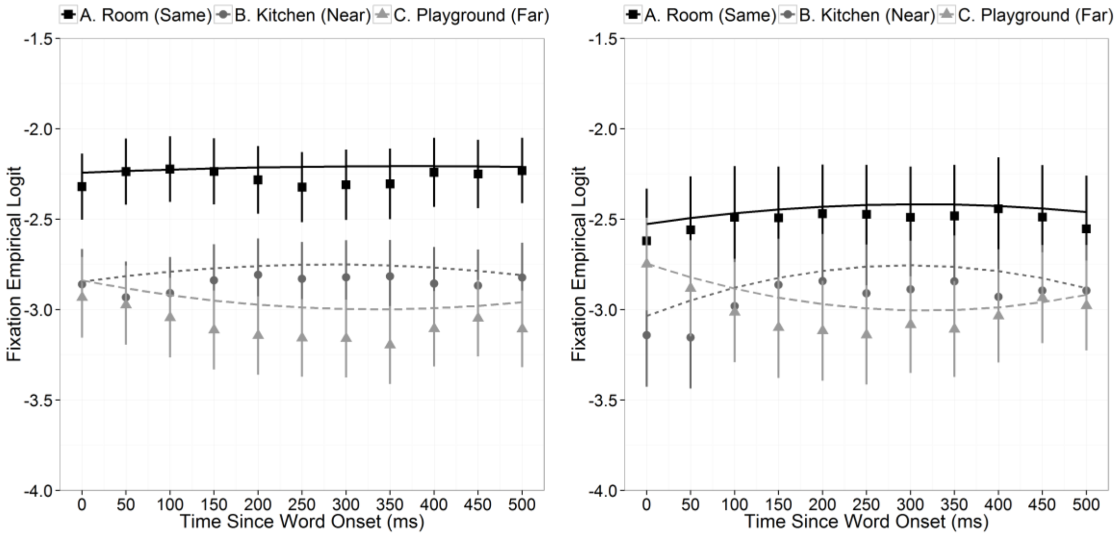

Figure 2.6. Model fits and fixations (transformed data) by participants (Left; N=54) and items (Right; N=35) to the target and competitor during the anticipatory region ('about how the') as a measure of the protagonist's final location in Experiment 2; point-ranges represent the empirical logit and their standard errors

For by-participants and by-items models, the overall time course of fixations was captured using second-order (quadratic) orthogonal polynomials with fixed effects of condition (Room vs. Kitchen, Playground) on both time terms. Both models used a maximal converging random effects structure (Barr et al., 2013), with random effects of participants and participants nested within condition on both time terms for the by-participants analysis, and with random effects of item and item nested within condition on both time terms for by-items analysis. In both by-participants and by-items models, dummy coding was used such that the Room (Same) condition initially represented the baseline in each model. In order to obtain comparisons for the Kitchen (Near) and Playground (Far) condition, contrasts were performed using the `glht` function from the `multcomp` library (version 1.4-0), adjusting for multiple comparisons using the single-step method. For full model examples, see Appendix B.2. For both models, statistical significance for individual parameter estimates was calculated using the normal approximation. Parameter estimates for all contrasts across both types of model are shown in Table 2.8.

Table 2.8. By-participants [1] (N=54) and by-items [2] (N=35) contrasts of parameter estimates for the transformed fixations on the target (‘picture’) and competitor (‘chair’) during the anticipatory region (‘about how the’) as a measure of the protagonist’s final location in Experiment 2

Contrast	*β*	*SE*	z-value	Pr(>|z|)
Room vs. Kitchen [1]				
Intercept	-0.564	0.098	-5.741	<.001***
Linear	0.007	0.102	0.066	1.00
Quadratic	-0.067	0.048	-1.397	.704
Room vs. Kitchen [2]				
Intercept	-0.391	0.082	-4.773	<.001***
Linear	0.090	0.098	0.914	.946
Quadratic	-0.145	0.035	-4.154	<.001***
Room vs. Playground [1]				
Intercept	-0.735	0.099	-7.468	<.001***
Linear	-0.166	0.103	-1.550	.596
Quadratic	0.127	0.049	2.592	.074+
Room vs. Playground [2]				
Intercept	-0.480	0.082	-5.855	<.001***
Linear	-0.254	0.098	-2.593	.075+
Quadratic	0.274	0.035	7.849	<.001***
Kitchen vs. Playground [1]				
Intercept	-0.170	0.099	-1.728	.467
Linear	-0.166	0.103	-1.604	.556
Quadratic	0.194	0.050	3.885	<.001***
Kitchen vs. Playground [2]				
Intercept	-0.089	0.082	-1.083	.886
Linear	-0.343	0.098	-3.496	.004**
Quadratic	0.419	0.036	11.764	<.001***

***p<.001; **p <.01; *p <.05; +.1< p<.05

From Table 2.8, it is clear that for the intercept, the target and competitor were fixated more often in the Room condition than the Kitchen (p_1<.001; p_2<.001) and Playground conditions (p_1<.001; p_2<.001). However, there was no significant difference in fixations on the target and competitor for the Kitchen and Playground conditions (p_1=.467; p_2=.886). Thus, across the entire anticipatory time-window, participants were more likely to fixate the target and competitor in the Room condition than in the Kitchen or Playground conditions. For the linear term, there was no significant difference in the rate of growth for fixations on the target and competitor in both by-participants and by-items analyses for the Room vs. Kitchen comparison (p_1=1.00; p_2=.946), and there was no reliable difference in the rate of growth for fixations on the target and competitor (on the linear term) in both by-participants and by-items for the Room vs. Playground (p_1=.596; p_2=.074), and Kitchen vs. Playground comparisons (p_1=.556; p_2=.004). Taken together, these results suggest that during an anticipatory region only, potential targets were more accessible throughout the entire time window if a spatial shift has not occurred within the discourse.

2.4. General Discussion

Experiments 1 and 2 explored how space is represented in an event model during language comprehension, with the aim to determine whether participants represent space in a categorical (i.e. room by room, or whether a shift occurred or not) or Euclidean (i.e. metrically) manner. In both experiments, participants listened to discourse narratives describing a protagonist either staying in one location (Room), moving to a near location (Kitchen), or moving to a far location (Playground) in respect to the initial location. Crucially, this meant that while the Euclidean distance travelled by the protagonist increased incrementally across conditions, the number of categorical shifts remained the same in the two ‘spatial shift’ conditions. In Experiment 1, participants took part in this task while viewing a visual scene depicting the initial location and several objects contained within it, and in Experiment 2, participants took part in the same task but while the visual scene was replaced with a blank screen. In both experiments, the proportion of fixations on objects (or to where objects were previously) within the visual scene was taken as a measure of accessibility for said objects during language processing. It was predicted that any difference in fixations on the target object upon mention would reveal the metric of space used during language comprehension: if the proportion of fixations decreased incrementally as the Euclidean distance between the protagonist and the initial location increased, this would be taken to support a Euclidean or non- or partially-hierarchical representation of space. If, however, the proportion of fixations decreased only as a measure of whether a categorical shift has occurred, this would be taken to support a categorical or hierarchical representation of space.

In Experiment 1, during the critical noun region (‘picture’) there was no difference in the fixation probability for the target as a result of either categorical or Euclidean shifts in space throughout the entire time window. However, focusing on the reliable differences across both the by-items and by-participants analyses, the rate of access for the target was slower (on the linear term) if the protagonist made a shift to a far-away location (vs. staying in the initial location or moving to a near location). These results indicate that, when concurrently viewing a visual scene, the overall accessibility for a target on mention is not influenced by any metric of space, but the rate of access is influenced by whether or not the protagonist made a shift to a far-away location only. Experiment 2 did not replicate the difference in the rate of access for the target object on mention found in Experiment 1. Instead, space did not affect either accessibility for the target object throughout the entire time window or the rate of accessibility for the target object as time progresses. However, during an anticipatory region (based on probabilistic learning throughout the experiment) prior to the onset of the critical noun, categorical distance, but not Euclidean distance influenced accessibility for potential targets. Specifically, in this region participants were more likely to fixate on potential targets throughout the entire time window if the protagonist remained in the initial location, rather than moving to a new location. As such, this experiment showed effects of categorical distance in the predicted direction, but during an earlier region than expected.

While Experiment 2 found no reliable difference across conditions for the rate of access for the target or potential targets, Experiment 1 found that the target was less accessible on mention of the critical noun in the Playground (far) condition when compared to both the Room (same) and Kitchen (near) conditions. However, the direction of effect found in Experiment 1 is not consistent with the initial predictions made to fit with either a Euclidean or categorical account. One explanation for this finding is outlined in Section 2.2.3: EST (Radvansky & Zacks, 2011) proposes that event boundaries are perceived at distinct changes in locations, and that creation of a new event model only occurs when the ongoing sequence of events cannot be accurately predicted by the current model, otherwise changes in the sequence of event are accommodated by transforming the current model. It is possible that if the Kitchen location was seen to belong to a similar superordinate location as the Room location (i.e. a house), as was the case in most of the stimuli, then one event model could have been used to represent both the Same (Room) and Near (Kitchen) locations, but a new event model would be required to represent the Far (Playground) location. If so, it is plausible that the rate of access for the target should be higher in both the Room and Kitchen conditions when compared to the Playground condition, as in these cases no new event model has been made, and focus remains on the current working event model that contains the target object. However, such an interpretation fails to account for the higher level of accessibility for potential targets throughout the entire anticipatory time-window in Experiment 2, and also fails to account for the lack of any similar effect on the noun in Experiment 2. Instead, an alternative explanation is more plausible.

Rinck and Denis (2004) found that, during a mental imagery task, participants represented both Euclidean and categorical distance, and that both metrics of space influenced accessibility for target objects. Here, the effects of Euclidean and categorical distance were found to be additive, but the effect of Euclidean distance was weaker than that of categorical distance. Indeed, while many studies have shown that as the Euclidean distance between an initial location and a protagonist increases so do reaction times when responding to probe tasks about the target, such effects have largely been non-significant (Morrow et al., 1989, 1987; Rinck & Bower, 1995), which Rinck et al. (1998) argue is due to a lack of power in these studies, highlighting that Rinck and Bower only found an effect of spatial shifts when combining the results of four experiments containing a total of 168 participants. Thus, in Experiment 1, it is plausible that Euclidean distance affected the rate of accessibility, but this was only found in the rate of accessibility and only in the Playground condition (vs. Room and Kitchen conditions) because the Euclidean distance travelled was relatively large when compared to the Kitchen condition, with any differences between the three conditions being too small to be detected by any analyses. Moreover, it is likely that this effect was only present in Experiment 1 as in general objects in this experiment received a larger proportion of fixations when compared to Experiment 2, potentially allowing for detection of small differences in the rate of access across conditions.

Reconciling the greater levels of accessibility for potential referents during an anticipatory region in the Room condition when compared to the Kitchen and Playground conditions in Experiment 2 with the slower rate of accessibility in the Playground condition (vs. Room and Kitchen conditions) on the linear term during the critical noun in Experiment 1, it is likely that Euclidean distance can affect the rate of access for targets (i.e. Experiment 1), but categorical distance affects the overall accessibility for potential targets during anticipatory language processing (i.e. Experiment 2). Focusing primarily on this difference in levels of accessibility throughout the entire time-window, the main finding from these two experiments is that the degree to which participants anticipate potential referents during discourse processing is related to whether a shift to a new location has been made (or not), but only when the initial visual scene is removed prior to the onset of the narrative discourse; supporting a view that the metric of space used when accessing information from an event model is centred around categorical representations more so than Euclidean distance. The findings that a categorical shift reduces the overall accessibility for potential targets during an anticipatory window (in Experiment 2), and that the overall accessibility for referents is equivalent across different Euclidean distances if a categorical shift has been made (in Experiment 2), are in line with a partially-hierarchical theory of spatial memory (McNamara, 1986; McNamara, 1992). In this theory, it is thought that information is grouped primarily by regional belonging and that while a representation of Euclidean distance can be maintained it is not always necessary in order to build a mental representation of space. Specifically, any effect of Euclidean distance on access for a target is typically strongest when focusing on spatial relations within a categorical location rather than between categorical locations, but Euclidean distance can still have minimal effects between categorical locations (McNamara, Hardy, & Hirtle, 1989; McNamara, 1986). Here, then, it is possible that categorical space outweighs Euclidean distance in terms of the overall accessibility for potential targets, but that a weaker effect of Euclidean distance may still influence the rate of accessibility for targets (in Experiment 1). Moreover, given that the influence of Euclidean distance on the rate of access was only found when a relatively large shift in space has been made, this suggests that the influence of this metric of space for accessing targets (in Experiment 1) is either weak or transitive in nature. Together, these findings suggest that, due to spatial information being categorised in nested levels of detail, if a higher level (i.e. categorical or regional information) is good enough for the task at hand then lower levels of detail (i.e. Euclidean distance information) likely have little impact on accessibility for the potential targets during discourse processing.

Crucially, however, both experiments did not find a general effect of accessibility driven by space during the critical noun region. While research by de Vega (1995) has shown that event model updating should occur only when reference is made back to an integrating piece of information (i.e. the name of the target object), the lack of support for this in the first two experiments reported here is not altogether unexpected given the current paradigm. It is plausible that on mention for the critical noun either in the presence of a visual referent (i.e. in Experiment 1), or not (i.e. in the blank screen; Experiment 2), that low-level referential processing occurred, in which eye-movements were guided primarily by factors aside from the event model, simply reflexively fixating on the visual referent (or its previous location) on mention – using this mechanism for access in order to relieve working memory load (Ballard et al., 1997). Furthermore, it has been suggested that event models are only used in comprehension when they are necessary for it (McKoon & Ratcliff, 1992; Zwaan & van Oostendorp, 1993); on mention for the critical referent, and with visual correlates for the referent, it is likely that an easier mechanism than using an event model was employed for identifying the target. This could explain why in both experiments there was no difference in the overall accessibility for the target on mention. Why, then, did categorical distance influence the overall accessibility for potential targets in Experiment 2 but not in Experiment 1? Because the visual scene was removed prior to presentation of the discourse, the initial location was not visually foregrounded across the conditions as a likely focus for the narrative. In doing so, it is possible that participants focused on the most relevant source of information for understanding the unfolding narrative; the event model. Whereas if the visual scene remained on-screen, it is possible that this drew attention away from the event model as a source to understand the upcoming language (and potential targets), causing participants to instead focus on what was immediately visually present, and thus relevant. This could explain why in Experiments 1 and 2 space did not influence accessibility for the object on mention. In Experiment 2 it is plausible that participants actively attempted to predict the unfolding narrative based on their event model, accounting for differences in the rate of access and overall accessibility for potential targets during the anticipatory region. Whereas in Experiment 1, it is possible that participants primarily focused on the ‘here and now’, only observing a difference in the rate of accessibility for the target on mention, but no difference in the overall accessibility for the target likely due to low-level referential processing masking any difference here caused by the makeup of the event model.

de Vega (1995) notes that to update a mental model new information must be provided (often via anaphoric reference) and integrated into the current model. Following a spatial shift, mentioning an object associated with a different event model (i.e. the picture in the room) forces participants to update the event model and brings focus back to the previous event model and location (i.e. the room), foregrounding this location even if the protagonist is not physically within the previous location (Morrow et al., 1989). Yet, during the anticipatory region neither the previous location nor the objects contained within it are mentioned; thus focus is maintained upon the current event model (and thus the current location). This results in the reported effects of lower overall accessibility for potential targets if a spatial shift has been made (at least in Experiment 2), which is more likely to be long lasting throughout the anticipatory time-window. In contrast, on mention for the target attention must switch back to the event model containing the target following a spatial shift, a process associated with an increase in processing costs (Morrow et al., 1989; Radvansky, 2012). What is not known, however, is how quickly this switch in attention occurs, or whether or not such switching costs can be detected using eye-tracking methods. Analysing accessibility for potential targets during an anticipatory region likely offers a more sensitive measure of accessibility for information maintained in the event model and a better means for understanding how space is structured in the event model as this avoids confounds associated with low-level referential processing, but also maintains focus on the working event model; in cases where a spatial shift has been made, it is likely that information in the initial location (i.e. the backgrounded event model) remains at a lower level of accessibility throughout the anticipatory time-window than if the initial location was maintained in the foreground. Indeed, this interpretation finds support from research by Whitney, Ritchie, and Crane (1992) who found that readers can make predictive inferences from text, but only when that information is foregrounded. Thus, we are more likely to anticipate or infer what might come next in a narrative if that information is in the foregrounded event model, but we are less likely to do so if it is backgrounded.

Focusing upon the primary finding of these two experiments, that anticipation for potential referents is lower when a categorical shift has been made (vs. not) during a blank-screen task, this result is interesting for a number of reasons: It suggests that whether or not the structure of an event model influences accessibility for discourse referents is primarily dictated by spatial categorisation and not Euclidean distance, in-keeping with the Event Horizon model (Radvansky, 2012). Moreover, contrary to previous findings, the current results also show support for the spontaneous tracking of spatial information without an explicit task (cf. Hakala, 1999; Zwaan & van Oostendorp, 1993) as language unfolds, and that the accessibility for objects during anticipatory processing is mediated by the number of categorical shifts contained within a narrative. By taking advantage of the notion that objects that are mentioned are marked as being integral to a story, and thus are held in the explicit focus of the narrative (in contrast to unmentioned objects), it is apparent that it is possible to anticipate that one of these two objects will be mentioned again (McKoon & Ratcliff, 1992). However, the current results are unique in that they show that this process is mediated by whether or not focus is being maintained upon the event model containing these objects due to whether or not a categorical shift has occurred, and that this process occurs during on-line processing. Thus spatial categorisation influences how language is incrementally processed and the extent to which prediction occurs during discourse comprehension. In contrast to Sundermeier, van den Broek, and Zwaan (2005) the current findings indicate that participants can keep track of spatial changes in a story without the need to memorise a map first; we are able to infer spatial relations from narratives with no prior knowledge of layout or the distance between locations. Even when not instructed to track space or, indeed, anything within the narrative, categorical space influences the allocation of visual attention during discourse processing (cf. Hakala, 1999; Zwaan & van Oostendorp, 1993). Thus, spatial information is tracked spontaneously and without the need for an overt task, influencing accessibility for information (i.e. the target) during narrative comprehension. However, an event model is likely only used when it is necessary for comprehension (e.g. in the blank-screen paradigm) and when external factors (e.g. concurrent visual scenes) do not draw attention away to a competing source of information, or a competing event model.

The results of both experiments cannot be due to differences across conditions in the plausibility of the events described in the final sentence – the norming questionnaire described in Section 2.2.1.4 found that as the distance from the initial location increased, the plausibility of the actions, and thus whether or not the target would be mentioned in the final sentence decreased. de Vega (1995) found that if readers encounter information, such as a sentence, that is spatially inconsistent with the protagonist's location (e.g. 'Carmen went out of the museum. She approached the mummies quietly.': de Vega, 1995, p. 375) during a narrative, that reading times at the inconsistent sentence are increased; essentially, it is difficult to reconcile spatially inconsistent information with the current event. This is likely driven by the plausibility of mention dictated by spatial location, however, critically, the current experiments showed while the plausibility of mention for the target decreased gradiently as Euclidean distance increased, this similar pattern of results was not found in the accessibility of the target (or potential targets). As none of the results reported here follow this pattern of effect in accessibility, it is unlikely that plausibility played major a role in the current findings. Finally, the results reported here confirm that eye-tracking provides a sensitive measure for the rate of accessibility and overall accessibility of discourse referents following spatial shifts during anticipatory processing, depending upon the paradigm employed, thus justifying the use of this and similar paradigms for exploring the role of event models on language comprehension.

Although the current experiment seems to strongly implicate categorical distance as the primary metric of space to influence object accessibility, it is possible that in the current experiment Euclidean distance had no effect upon the overall accessibility of targets and potential targets due to the distances between locations not being as clearly illustrated as those using map-learning (e.g. Morrow et al., 1987; Rinck & Bower, 1995; Rinck & Denis, 2004) or spatial priming (McNamara, 1986) tasks. McNamara found that reaction times during a recognition task, in which participants had to respond whether an object was located in the a layout, were faster when probe words (e.g. object names) were preceded by an object name which was located in the same region. Further judgments of distance showed that Euclidean distance was encoded during learning, but was often distorted if objects were located across a boundary. It is possible that because the present study did not display all locations (i.e. only the start location was shown), and as such no clear visual represenation was provided to highlight the metric distance between locations, that inferences of Euclidean distance would be more difficult, and perhaps more distorted given the current paradigm. As such, this could bias towards a categorical representation of space. Indeed, recalling the issue of visual foregrounding in Experiment 1, it is also plausible that in both experiments participants were biased to focus primarily on the initial location, potentially reducing or removing any effects of space during anticipatory processing or upon mention of the target respectively. Improvements to the current paradigm would either involve displaying all locations mentioned in the narrative in the initial visual scenes, or displaying none at all and using an empty display only depicting the objects themselves divorced from any spatial context.

Considering the findings of the present study in light of the current literature, we are also left with the question of what is causing more fixations on the target and competitor in the Room (Same) condition. Is the pattern of results due to inhibition driven by categorical shifts, resulting in fewer anticipatory fixations on potential targets when a categorical shift is made (Radvansky & Copeland, 2006)? Or facilitation driven by the foregrounding of objects in the No-shift condition (i.e. Room (Same)), resulting in more anticipatory fixations on potential targets if the protagonist is in the same location as the referents (Albrecht, O'Brien, Mason, & Myers, 1995; Glenberg et al., 1987)? The likely answer to these questions, considering that both foregrounding and categorical shifts influence accessibility for information in an event model (Radvansky, 2012), is that both of the mechanisms underpin the results of the current experiments. Moreover, foregrounding (i.e. the greater accessibility for objects in the same location as the protagonist (vs. different locations)) can often be confounded with encoding-specificity (i.e. the greater accessibility for objects at retrieval if the retrieval and encoding scenarios are the same (vs. different); see Tulving & Thomson, 1973). Both foregrounding and encoding-specificity predict a greater level of accessibility for objects in the Room (Same) condition when compared to the two Shift conditions, however the findings of Radvansky, Krawietz, and Tamplin (2011) suggest that event structure plays a more prominent role than encoding-specificity in influencing object accessibility during event segmentation tasks: Radvansky et al. conducted a virtual reality task in which participants had to move between rooms whilst carrying objects to be placed in new locations and found response errors for an object-probe task to increase as more *new* rooms were encountered, with returning to a previous location (i.e. the location of encoding) providing no improvement in performance on the response-probe tasks. While it is still possible that encoding-specificity could drive the findings of the current experiments, given such findings it is more likely that foregrounding and/or spatial shifts are the cause of the difference in accessibility for the potential targets across conditions in Experiment 2. Thus, to parse out whether foregrounding or spatial shifts can independently influence object accessibility during narrative processing, and to observe whether encoding-specificity played a role in the current findings, Experiment 3 will use a similar methodology to that of Experiments 1 and 2, but will introduce multiple locations and movement of a protagonist involving shifts either to or from an initial location. Further, considering the concerns with visual foregrounding across both experiments, this experiment will remove any context of location in visual scenes, using a blank quadrant of objects only.

Currently, the results of these two experiments suggest that space is represented during online narrative comprehension, and that participants spontaneously track categorical relations between locations. Furthermore, these categorical relations have been shown to influence access for potential referents during anticipatory processing, even in the absence of an overt task, but only when no concurrent visual scene was presented. While some effect of Euclidean distance was found in the noun region (in Experiment 1) on the rate of accessibility for targets, these findings do not fully support a gradient account for accessibility; instead, only large increases of Euclidean distance sufficed to reduce the rate of accessibility. Moreover, the only metric of space found to influence accessibility during the whole time window was that of categorical distance (in Experiment 2). Thus, it can be inferred that while Euclidean distance may be maintained, and may influence the rate of accessibility for information during narrative comprehension, it is likely that spatial representations are primarily based around, and influenced by, categorical space; distinctive locations outweigh distance in discourse processing.

Chapter 3

Spatial Updating Effects on Objects Maintained in Foregrounded or Backgrounded Locations

3.1. Experiment 3

3.1.1. Introduction

Experiment 2 has provided evidence that, during the region prior to the referent (i.e. the anticipatory region), objects in the foregrounded event model are more accessible if a shift has not occurred, and following a shift to a new location, objects in the same (now backgrounded) event model are less accessible. However, it remains unclear whether the driving factor behind these effects is a difference in foregrounding/backgrounding (i.e. whether the target is in the working event model or not) or the number of spatial shifts to new locations across conditions. The question remains, is the target object more accessible when in the foregrounded event model, or is the target object less accessible following a spatial shift? It is likely that the answer to this question is simply ‘both’ considering the wealth of research highlighting correlated effects of foregrounding and spatial shifts (Glenberg et al., 1987; Morrow et al., 1989, 1987; Rinck & Bower, 1995; Whitney et al., 1992). However, further exploration is warranted to assess the relative contribution of these two factors (if any).

In the situation model literature, narrative comprehension studies (e.g. Morrow et al., 1989; Rinck & Bower, 1995) have shown a linear decrease in accessibility for objects in the goal, path, and source locations – showing that, when controlling for foregrounding, accessibility for probed-for information is influenced by a spatial shift (i.e. whether or not an event boundary has been crossed). While evidence from the experience model literature has shown that even when an object is in the foregrounded event model (e.g. room) as more spatial shifts are made to unique locations the object becomes less accessible (Radvansky et al., 2011). Crucially, in this experiment Radvansky et al. manipulated not only whether a spatial shift was made but whether this shift was associated with moving to a new room or a previously-encountered room. In doing so, it was possible to explore the contribution of a spatial shift on accessibility even when information was maintained in the foregrounded event model (i.e. room). Here, Radvansky et al. found that the effects of a spatial shift in terms of accessibility for the target during response probe tasks differed depending on the number of shifts to new locations; making a spatial shift to a new location before returning to a previously-encountered location was more similar to making a single shift to a new location than a making a double-shift (i.e. to two new locations) in terms of the error rates in response-probe tasks. This suggests that not only are the categorical distance effects reported in previous experiments (e.g. Morrow et al., 1989; Rinck & Bower, 1995), including

Experiment 2 of the current thesis, likely due to shifts to *new* locations, but that returning to a foregrounded location does not eliminate the negative effects associated with a spatial shift in regards to object accessibility. This research has fed into Event Segmentation Theory (Radvansky & Zacks, 2011; Zacks et al., 2007) which suggests that as a new location is encountered, a new event model must be constructed and maintained, and the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) which argues that that as more event models are maintained this reduces accessibility for a target object.

Previous research in the narrative comprehension literature has shown that when a spatial shift is made, accessibility, in terms of reaction times for probed-for information, decreases (Morrow et al., 1989, 1987; Rinck & Bower, 1995). In these experiments, participants typically memorise a map of several locations containing multiple objects before reading a narrative describing the movement of a protagonist through these locations. In general, participants are quicker to respond to probes for information in the current location of the protagonist, and slower to respond to probes for information outside of this location. When divorcing the effect of foregrounding from a spatial shift, or only analysing the difference between probes one room and two rooms away from the initial location, although a linear trend often occurs, this difference in accessibility is rarely significant (for a review, see Rinck et al., 1998). Only when collapsing across several items and trials (e.g. Rinck & Bower, 1995) is a significant effect found. This suggests that, during narrative comprehension, the effect size of a spatial shift is likely to be small if it does indeed influence accessibility for information. However, in a series of virtual reality and real life experiments, Radvansky and colleagues (Radvansky & Copeland, 2006; Radvansky et al., 2011, 2010) have shown that when an object is carried by a participant from one room to another (rather than within one room), the object is less accessible even if maintained in the foregrounded event model/location. One reason for why an effect was found by Radvansky and colleagues is due to the paradigm employed; it is likely that when taking part in the events, and not just reading about them, the event model is richer and more readily influences memory retrieval (Beveridge & Pickering, 2013). Also, it is likely that in the tasks employed by Radvansky and colleagues the carried object was represented in both event models, a result of which is that competition between events is manifested in competition between the multiple object instantiations (i.e. the representations in the initial and final event model). This could mean that the negative influence of a shift on accessibility for the object could be driven by a different mechanism between the two tasks; general processing costs associated with updating and maintaining multiple event models in Rinck and Bower (1995), and competition between the two relevant event models/instantiations of the object in Radvansky et al. (2011).

In order to explore whether spatial shifts and foregrounding individually influence object accessibility in narrative comprehension, the current experiment aims to orthogonally manipulate these two factors. Crucially, the current study aims to explore the effects of a spatial shift in a way more similar to that of Rinck and colleagues (e.g. Rinck et al., 1998; Rinck & Bower, 1995) than Radvansky and colleagues (Radvansky & Copeland, 2006; Radvansky et al., 2011, 2010), asking whether a spatial shift by the protagonist, rather than the protagonist and target object, can reduce accessibility for the target object. This direction has been taken as it is presently unclear whether foregrounding and/or spatial shifts individually contribute to the accessibility of a target object on mention.

These implications of the results discussed above, and of EST (Radvansky & Zacks, 2011; Zacks et al., 2007) and the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) raise several issues with the results discussed in Chapter 2. For example, it is possible that the reduced accessibility for potential targets in Experiment 2 in the Shift conditions when compared to the No-shift condition was driven by an imbalance in the number of event models maintained, rather than any effect of foregrounding (e.g. Glenberg et al., 1987) or increased processing load associated with updating an event model following a spatial shift (Radvansky & Zacks, 2011). Furthermore, EST and the Event Horizon model are also unspecific about what constitutes a spatial shift to a new location during narrative comprehension; does a spatial shift reduce accessibility for information if this shift is made to a location that is new to the comprehender, or to a location that is new to the protagonist? Moreover, if a spatial shift is made to a previously-encountered location, then why is there little if any cost to updating the event model? Surely the need to update the event model is more costly to processing when compared to cases in which no updating is required (i.e. when no spatial shift is made at all). As such, it might be predicted that regardless of whether a shift is made to a unique location or not a spatial shift should still reduce accessibility for information associated with the narrative. The present experiment thus aims to explore whether a spatial shift reduces accessibility for a target during discourse processing when both locations are known to the comprehender but not to the protagonist, while also addressing whether the effects of foregrounding and spatial shifts individually influence accessibility for the target.

In Experiments 1 and 2, participants heard narratives describing a protagonist either staying in an initial location or moving to one of two new locations (either close-by or far-away from the initial location). In both cases, participants heard an initial sentence describing the initial location and the objects held within it (e.g. the room containing the picture and chair); the name of this initial location was then either repeated in a following sentence establishing that the protagonist stayed in the initial location, or a new location was mentioned in order to establish that the protagonist moved to a new location. While the narrative was structured in this way to accommodate a spatial shift (or not), this inevitably led to a discrepancy in the number of event models constructed across the three conditions: In the No-shift condition only one location was mentioned and thus only one event model needed to be constructed and maintained, whereas in both Shift conditions two locations were mentioned and thus constructed. It is possible that, similarly to the results of Radvansky et al. (2011), potential targets were less accessible during the anticipatory region in Experiment 2 in the Shift conditions (vs. No shift condition) due to the need to create and maintain a new event model to represent the new location, and not due to an increase in processing costs associated with a spatial shift in itself. Moreover, it is possible that potential targets were more accessible in the No-shift condition when compared to the Shift conditions because the initial location was more recently mentioned (and mentioned more often) before the critical region for analysis; thus, the reported effects of an increase in categorical distance leading to a decrease in accessibility for potential targets could in fact be due to a discrepancy in the surface distance between the target and the initial location across conditions (see Rinck, Bower, & Wolf, 1998).

A further concern with the paradigm employed in Experiments 1 and 2 is that potential targets were more accessible in the No-shift condition when compared to the two Shift conditions during an anticipatory region in Experiment 2, but that the No-shift condition was the only case in which the visual scene was visually co-present (Experiment 1) or initially depicted before being removed (Experiment 2). Due to this discrepancy, it is possible that during the anticipatory region such ‘visual foregrounding’ could actively compete with the mentally foregrounded location following a spatial shift, causing difficulty in interpreting the incoming discourse in this case. Moreover, if no shift has occurred this could also furnish the mentally foregrounded location with richer detail, causing an increase in accessibility for objects in this location. One further explanation for the results reported in Experiment 2 is that the decrease in accessibility for the potential targets following a spatial shift could simply reflect an effect of encoding-specificity (Tulving & Thomson, 1973), in which accessibility for information associated with one location decreases following a change in context. Following a virtual reality experiment by Radvansky et al. (2011), who found that when participants controlled an avatar around a virtual environment a spatial shift decreased accessibility for a held – and thus foregrounded – object even if the avatar returned to the initial location of encoding, it is unlikely that encoding-specificity is the factor behind the results of Experiment 2, however this factor could still play a role in influencing the results of Experiment 2.

Addressing the above concerns, the current experiment thus aims to orthogonally manipulate whether a shift has occurred (or not) within a narrative, and whether the probed-for object is in the foregrounded or backgrounded event model. The current experiment will display all objects mentioned in a quadrant with a white background, avoiding visually foregrounding any one location more so than another, an example of which is depicted in Figure 3.1, below.

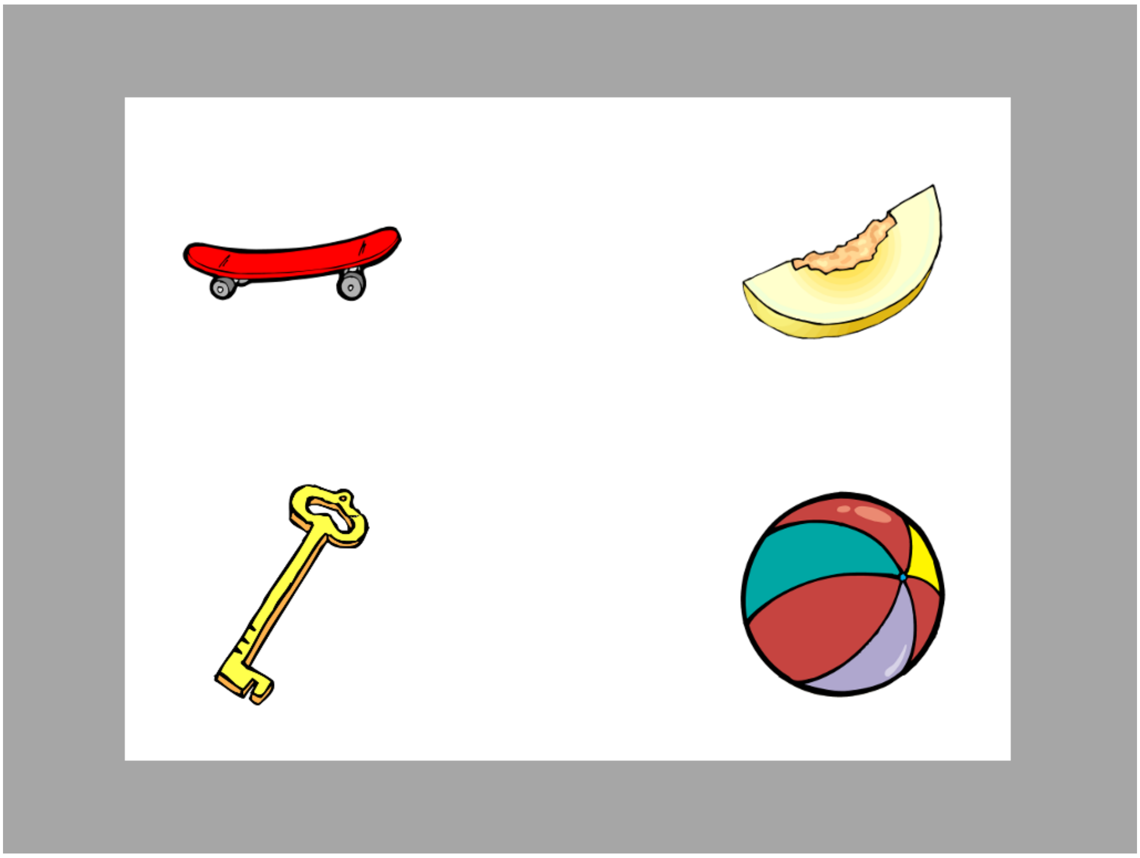

Figure 3.1. An example of the visual scene accompanying spoken sentences in Experiment 3, e.g. Example 3.1

In the present experiment, participants will view the quadrant displayed in Figure 3.1 for a short preview before hearing sentences such as those depicted in Example 3.1.

Example 3.1. An example of the linguistic stimuli used in Experiment 3

(1) The boy has put the skateboard and the key in the cafeteria, and the ball and the melon in the parlour.

(2a) His sister will walk around the cafeteria next to the parlour.

(2b) His sister will walk around the parlour next to the cafeteria.

(2c) His sister will walk from the parlour to the cafeteria.

(2d) His sister will walk from the cafeteria to the parlour.

(3) Then she will think about how the skateboard is quite steady.

In the present experiment, 2 characters were introduced such that one character (e.g. 'The boy') could plausibly introduce both locations and the objects within them even if the protagonist (e.g. 'his sister') does not move from one room to another. Introducing both locations and pairs of objects in each condition was crucial for the present experiment to balance the number of event models/locations maintained in each condition; a potential confound with the findings of Experiment 2, as discussed in Section 3.1.1. Moreover, by introducing both locations the length and complexity of the sentences is presumed to be more similar across conditions than if only one location was mentioned in the No-shift conditions (i.e. 2a, b). Here, it was assumed that comprehenders would focus on the protagonist (e.g. 'his sister') rather than the first character (e.g. 'the boy') once introduced as this was the most recently mentioned character in the narrative; thus, the location of the first character ('The boy') was not assumed to be the main focus for comprehenders. The experimental conditions pertained to whether the protagonist (e.g. 'his sister') stayed in one location (2a, b) or made a spatial shift to a new location (2c, d), and whether the target object was in the foregrounded event model (2a, c) (i.e. the same location as the protagonist) or in the backgrounded event model (2b, d) (i.e. a different location to the protagonist) prior to mention. Thus, in (2a) the protagonist made no spatial shift, staying in the initial location containing the target; in (2b) the protagonist made no spatial shift, staying in the initial location which did not contain the target; in (2c) the protagonist moved to a new location which contained the target; and in (2d) the protagonist moved to a new location which did not contain the target. In each condition, after re-mention of the target in (3) it was assumed that the event model containing the target would be accessed, either involving a switch of focus from one event model to another, as in (2b) and (2d), or not, as in (2a) and (2c).

Following sentence (2), sentence (3) re-mentioned one of the four objects (e.g. skateboard) initially mentioned in sentence (1); this target object and the three distractors appeared in each location of the visual scene (top left/right, bottom left/right) an equal number of times across items, with the permutations for the locations for each object pseudorandomised such that no combination of orders was repeated more so than any other. The order of mention for the target object in (1) was also balanced across all items such that the object mentioned in (3) could correspond to any of the four objects mentioned in (1), i.e. the position of the target object in (1) was mentioned first, second, third, and fourth in (1) an equal number of times across items. The sentences involving a spatial shift were fully counterbalanced across items, as depicted in Example 3.2, so that the direction of movement of the protagonist could occur *from* one location to another (i.e. 2a, c) or *to* one location from another (i.e. 2b, d) such that the order of mention for each location was balanced across items.

Example 3.2. An example of the two Shift conditions (foregrounded, backgrounded) in Experiment 3

> 1. The boy has put the skateboard and the key in the cafeteria, and the ball and the melon in the parlour.
>
> 2a. His sister will walk from the parlour to the cafeteria. (Shift, foregrounded)
>
> 2b. His sister will walk to the cafeteria from the parlour. (Shift, foregrounded)
>
> 2c. His sister will walk from the cafeteria to the parlour. (Shift, backgrounded)
>
> 2d. His sister will walk to the parlour from the cafeteria. (Shift, backgrounded)
>
> 3. Then she will think about how the skateboard is quite steady.

This counterbalancing was not possible for the No-shift conditions if both locations were to be mentioned, such that all No-shift condition items took the form of (2a) and (2b) in Example 3.1. Across all items the sentences and visual scenes only contained inanimate objects that were deemed to be ‘moveable’ by the first character in (1). Visual scenes did not depict the first character, the protagonist, or any of the locations mentioned throughout the discourse so as to not visually foreground any given location. By mentioning all four objects within the visual scene in (1), anticipation for the target (i.e. in terms of probability of re-mention) was predicted to be less likely than in Experiments 1 and 2 (25% vs. 50% probability of any mentioned object to be the target), thus the proportion of fixations on the target on mention will be analysed as a measure of accessibility. This should also encourage comprehenders to rely more often on the event model than any other factors, e.g. probability of mention, when accessing the target as this becomes more necessary for accurate comprehension (McKoon & Ratcliff, 1992; Zwaan & van Oostendorp, 1993). As such, this experiment will explore the locus of effects reported in Experiment 2, asking whether foregrounding and spatial shifts individually contribute to the accessibility of a target during online language comprehension.

It is predicted that, regardless of whether a shift has occurred or not, that objects should be most accessible when in the foregrounded event model (i.e. the model containing the protagonist). Also, when a shift occurs, it is predicted that accessibility for said object should decrease, irrespective of whether that object is maintained in the foreground or not. Finally, it is also predicted that these two factors should interact, such that objects in the foreground should be most accessible if no shift has occurred (vs. a shift having occurred); with similar findings for objects in the backgrounded event model. It is expected that, while Rinck and Bower (1995) required a large number of items and participants to find an effect, arguably due to a lack of power (see Rinck et al., 1998), that eye-tracking methodologies and growth-curve analysis should be more sensitive than reaction time measures to probe-response tasks (Mirman, 2014), allowing for better detection for any effect of a shift. Thus, the current experiment will explore the locus of effects reported in Experiment 2, observing whether spatial shifts and foregrounding individually contribute to object accessibility during online language comprehension – a question not yet explored in the narrative comprehension literature.

3.1.2. Method

3.1.2.1. Participants

Sixty (8 male) native speakers of English from the University of Dundee community (aged 18-29, *M* = 19.90, *SD*= 2.31) took part in this study for partial course credit. All participants had uncorrected vision, wore soft contact lenses, or wore spectacles, and had no known auditory, visual, or language disorders. No participants in this study had previously taken part in Experiment 1 or 2 of the present thesis.

3.1.2.2. Apparatus

The same apparatus used in Experiment 1 was used here excluding the eye tracker. Instead of using an SR Research EyeLink-II head-mounted eye tracker, an SR Research EyeLink-2000 desk-mounted eye tracker was used in tower mode. The EyeLink-2000 has a monocular sampling rate of 2000Hz, a spatial resolution of 0.01°, and an average accuracy of 0.25º -0.5º, tracking the pupil and corneal reflection. Visual scenes were presented on a 22 inch viewing monitor with a resolution of 1024 × 768 pixels running at 75Hz refresh rate. Participants sat approximately 24 inches away from the display and speakers. Nine-point calibration and validation was used at the start of the experiment and was repeated every 12th item. The corneal reflection and pupil were tracked at a sampling rate of 1000 Hz from the participant's dominant eye as determined from a short test in which participants centred a light-switch in the test room between a hole in a piece of card held at arm's length – participants then closed each eye independently to determine in which case the light-switch was still visible between the hole in the card; the dominant eye was determined as the eye that was open when the light switch did not move from the centre of the hole in the card. Throughout the experiment viewing was binocular.

3.1.2.3. Materials

Forty-eight experimental quadrants (see Figure 1) were paired with spoken discourses consisting of three sentences (1-3). There were four sentential conditions (2a-2d) that correspond to the four manipulations of sentence 2 presented in Example 3.1. Four fixed-random lists were created for the stimuli. Each list contained one version of the four sentential conditions for each item. The order of presentation for items was randomised for each participant, with a maximum run length of 2 for condition such that only two items from the same condition could be displayed sequentially before an item from another condition followed. The experiment contained no filler items in order to increase the power of the experiment given the greater number of conditions (vs.

Experiments 1 and 2), and to improve comprehension for the discourse by always playing sentences with a regular structure. (This concession was made as a potential cause for the low proportion of fixations on the target object on mention in Experiments 1 and 2 was the irregular structure of the sentences across filler and experimental items.) However, given that the discourse-final target noun could be one of four potential candidates mentioned previously in the discourse, it was anticipated that prediction for the correct target would be low in this experiment. For a full list of the sentential stimuli used for recorded sentences, see Appendix C.1. For examples of all visual scenes, see Appendix C.2. One research assistant (Ruth Corps) helped with the development of materials for this experiment: Duties involved splicing the recorded audio files for each item and developing the visual displays by combining the images of each object with the blank background in a pseudorandomised order.

3.1.2.4. Procedure

A similar procedure to Experiment 1 was employed here. Participants took part in a look and listen task (e.g. Altmann, 2004). Each visual scene remained on-screen for the duration of the trial (average of 19,049msec) so that the visual stimuli and auditory stimuli were presented concurrently. Participants completed 4 practice trials, similar in type to the experimental items (with 1 for each condition), at the beginning of the experiment, after which they had the opportunity to ask any questions prior to the continuation of testing. Following the practice section, participants were given the opportunity to ask the experimenter any questions before starting the experiment. The experimental session consisted of 48 items outlined in Section 3.1.2.3. For all trials, each scene was displayed for a preview of 1000msec and remained on-screen for the duration of the trial (average of 23,049msec). After the 1000msec preview of the visual scene, the first sentence played. The second sentence played 1000msec after the offset of the first sentence. 500msec after the offset of the second sentence, the third (critical) sentence was played. Each individual trial was automatically terminated 4000msec after the offset of the final sentence. Table 3.1 shows the average onset, offset, and duration for each region, taking into account variability with onsets as a result of the experimental program. The full testing session lasted approximately 35 minutes. One research assistant (Ruth Corps) helped with testing of participants; testing 44 of the 60 participants in this study.

3.1.3. Results

3.1.3.1. Looks on the target (skateboard) 200ms after the onset until 200ms after the offset of the critical noun ('skateboard')

Data were prepared and analysed using R version 2.15.0 (R Development Core Team, 2008), using the `lme4` package (version 1.0-5). A similar method of analysis used in Experiment 1 was used here, with the data down-sampled from a 1000Hz temporal resolution so that fixations were reported every 10ms, aggregated across 50ms time bins. The mean duration of fixations was calculated for each time window.

Table 3.1. Mean durations of temporal regions in the experimental sentences (ms) in Experiment 3

Label	Region	Onset	Offset	Duration
Sentence 1	'The boy has put the skateboard (target) and the key in the cafeteria, and the ball and the melon in the parlour.'	1065	9215	8150
Sentence 2	'His sister will walk around the cafeteria/parlour next to the parlour/cafeteria. His sister will walk from the cafeteria/parlour to the parlour/cafeteria.'	10215	14320	4105
Sentence 3				
verb phrase	'Then she will think about how'	14820	16750	1930
determiner	'the'	16750	16870	120
critical noun	'skateboard' (target)	16870	17340	470
adjectival phrase	'is quite steady'	17340	19050	1710

The transformed data for the average proportion of fixations on the target (skateboard) is reported during the critical noun region ('skateboard') in sentence 3, with the average proportion of fixations shown in Figure 3.2 (with means and *SD* also reported in Table 3.2).

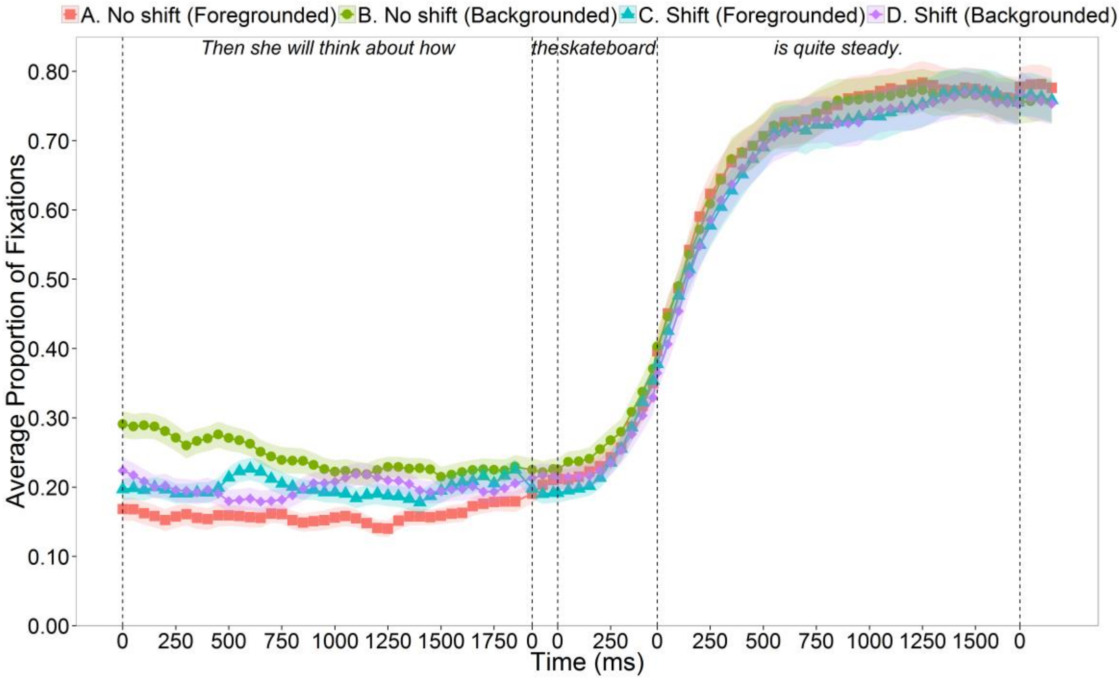

Figure 3.2. Average proportion of fixations on the target (skateboard) by participants (N=60) as a measure of whether the target is foregrounded (or not), and whether a spatial shift has occurred (or not) in Experiment 3; shaded bands show standard error

Figure 3.2 shows the average proportion of fixations on the target (skateboard) by participants across conditions, the values of which are reported 200ms after the onset until 200ms after the offset of the critical noun ('skateboard') in Table 3.2. The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

Table 3.2. Means (*SD*) for the proportion of fixations on the target (skateboard) 200ms after the onset until 200ms after the offset of the critical noun ('skateboard') as a measure of whether the target is foregrounded (or not), and whether a spatial shift has occurred (or not) in Experiment 3

	No-Shift	Shift	Total
Foregrounded	0.352 (0.206)	0.335 (0.186)	0.343 (0.196)
Backgrounded	0.368 (0.206)	0.333 (0.208)	0.350 (0.208)
Total	0.360 (0.206)	0.334 (0.197)	–

Empirical logit analyses were conducted to analyse the average fixations (log odds scale) on the target (skateboard) 200msec after the onset until 200ms after the offset of the critical noun ('skateboard'). Two models were created and run separately for by-participants and by-items analyses respectively, exploring the main effect of a whether the target was foregrounded or not, and whether a shift had occurred (or not) in regards to the movement of the protagonist, and their influence on fixations on the target over time, with time modelled as a fixed factor using orthogonal linear polynomials. Inspection of the observed transformed data in Figure 3.3 revealed a linear increase in fixations on the target object 200msec after hearing the critical noun, in line with theoretical predictions for the observed data pattern (see Section 2.2.2.1). As such, first-order (linear) orthogonal polynomials were preferred over higher-order orthogonal polynomials in this analysis (Mirman et al., 2008), and analyses were time locked to 200ms after the onset until 200ms after the offset of the critical noun (‘skateboard’).

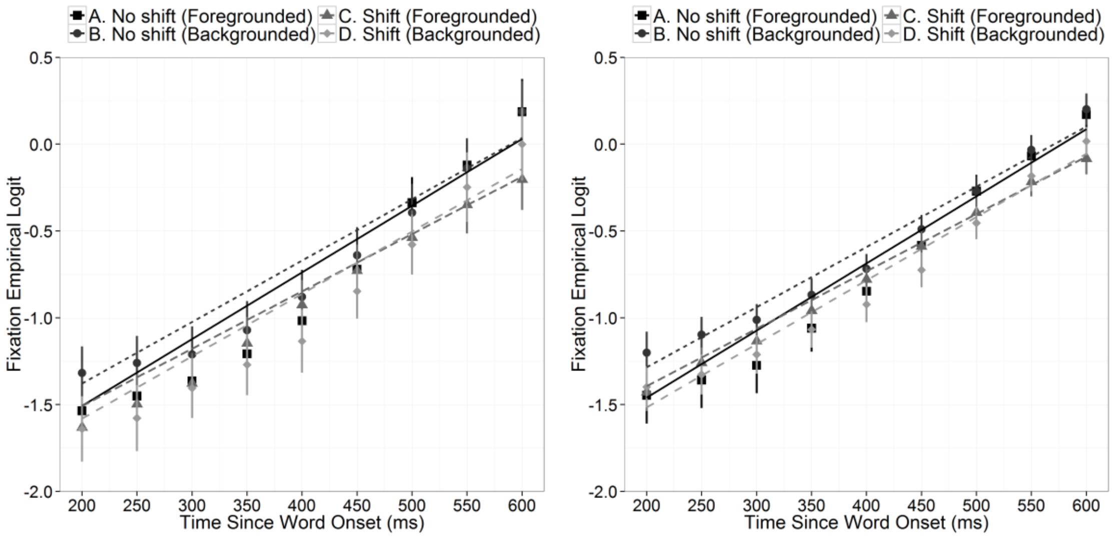

Figure 3.3. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=48) on the target 200ms after the onset until 200ms after the offset of the critical noun region (‘skateboard’) as a measure of whether the target is foregrounded (or not) and whether a spatial shift has occurred (or not) in Experiment 3; point-ranges represent the empirical logit and their standard errors

Unlike Experiments 1 and 2, the present experiment used a 2 × 2 design which did not necessitate multiple comparisons. However, in order to obtain main effects and interactions, deviation coding was used such that the parameter estimates represent the mean difference in log odds between conditions (Barr, 2008). In both the by-participants and by-items models, the baseline for each model was the difference between the levels of a given factor. In the current experiment, the two levels for Shifts – No shift and Shift, were coded as -.5 and .5 respectively, with the two levels of Foregrounding – Backgrounded and Foregrounded, coded as -.5 and .5 respectively (see Appendix C.3. for an example). In doing so, and with using linear orthogonal polynomials for the time term, the intercept parameter represents the grand mean of all four conditions throughout the entire time window. The linear term also represents the linear rate of change in the transformed data across all conditions. For the Shifts and Foregrounding terms, the baseline for these factors is centred at the mean of both levels, such that the value (positive or negative) in parameter estimates shows the direction of effect for each factor. A similar interpretation can be made for the interaction terms, with only the final factor in the interaction terms allowed to vary across levels.

The by-participants and by-items models used a maximal converging random effects structure (Barr et al., 2013), with random effects of participants and participants nested within both Shifts and Foregrounding factors on the intercept and slope terms for the by-participants analysis, and with random effects of item and item nested within both Shifts and Foregrounding on the intercept and slope terms for by-items analysis. Both models contained fixed effects of the orthogonal linear time term, Shifts, and Foregrounding on the intercept and slope. For full model examples, see Appendix C.4. For both models, statistical significance for individual parameter estimates was calculated using the normal approximation. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 3.3.

Table 3.3. By-participants [1] (N=60) and by-items [2] (N=48) parameter estimates for the transformed fixations on the target (skateboard) 200ms after the onset until 200ms after the offset of the critical noun region (‘skateboard’) as a measure of whether the target is foregrounded (or not), and whether a spatial shift has occurred (or not) in Experiment 3

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-0.780	0.022	-35.890	<.001***
Linear	1.382	0.025	55.565	<.001***
Shifts	-0.150	0.016	-9.517	<.001***
Foregrounding	-0.027	0.016	-1.677	.093^{+}
Linear: Shifts	-0.093	0.022	-4.297	<.001***
Linear: Foregrounding	0.003	0.022	0.118	.906
Shifts: Foregrounding	0.082	0.032	2.592	.010*
Linear: Shifts: Foregrounding	-0.232	0.043	-5.351	<.001***
By-items [2]				
Intercept	-0.699	0.009	-75.751	<.001***
Linear	1.384	0.014	99.499	<.001***
Shifts	-0.120	0.013	-9.437	<.001***
Foregrounding	-0.021	0.013	-1.635	.102
Linear: Shifts	-0.072	0.017	-4.147	<.001***
Linear: Foregrounding	0.010	0.017	0.600	.549
Shifts: Foregrounding	0.146	0.025	5.778	<.001***
Linear: Shifts: Foregrounding	-0.290	0.035	-8.325	<.001***

****p*<.001; ***p* <.01; **p* <.05; $^{+}$.1< *p*<.05

Table 3.3 shows a significant difference between the Shifts conditions in a negative direction, showing a larger proportion of fixations on the target throughout the entire region of analysis if no shift has occurred in the preceding narrative (p_1<.001; p_2<.001). However, there was no significant difference between the two Foregrounding conditions (p_1=.093; p_2=.102).

For the interaction between the linear term and Shifts factor, a significant difference was found in a negative direction, indicating that as time goes on the probability to fixate the target increased in the No-shift condition when compared to the Shift condition (p_1<.001; p_2<.001). However there was no significant difference between the two levels of Foregrounding on the linear term (p_1=.906; p_2=.549). A significant 2-way interaction was found between the Shifts and Foregrounding factors (p_1=.010; p_2<.001). Through observing Figure 3.3, it is clear that across the entire time-window the target receives a larger proportion of fixations if no shift has occurred, and when the protagonist is in the backgrounded event model (vs. the foregrounded event model). A significant 3-way interaction was also found between the linear term and the Shifts and Foregrounding factors (p_1<.001; p_2<.001). Through observing Figure 3.3, it is clear that while initially starting at a lower proportion of fixations at the beginning of the region of analysis, as time goes on the probability to fixate on the target increases more rapidly in the No-Shift condition if the target is in the foregrounded event model (vs. the backgrounded event model). However, if a spatial shift has occurred then there is no difference in the probability to fixate on the target as time goes on regardless of whether the target is in the foregrounded or backgrounded event models.

3.1.4. Discussion

The present study manipulated whether the protagonist made a shift to a new location (or not) and whether the to-be-mentioned target object was associated with the foregrounded location (or not) (i.e. in the location containing the protagonist, or not), with an aim to explore whether spatial shifts and foregrounding individually contribute to event comprehension and/or object accessibility during online discourse processing. It was predicted that if a spatial shift had occurred, and/or the target object was in the backgrounded event model, that accessibility for the target object would be reduced in terms of fixations on the target upon mention of the critical discourse final noun. Two-hundred milliseconds after the onset of the critical noun until 200ms after the offset of the critical noun ('skateboard') fixations on the target object (i.e. skateboard) were less likely following a spatial shift. Furthermore, the rate of growth in fixations on the target throughout the time-window was slower following a spatial shift than if no spatial shift was made. This result confirms predictions made by EST (Radvansky & Zacks, 2011; Swallow et al., 2009; Zacks, Speer, & Reynolds, 2009), showing that changes in the spatial dimension of events (i.e. moving from one room to another) negatively impacts accessibility for information from working memory associated with the overall event representation; possibly due to the need to update the event model following a spatial shift. Taken together, these results indicate that throughout the entire time-window the target is more accessible, and the rate of access is quicker in the No-shift condition when compared to the Shift condition.

During the same time-window, no main effect of foregrounding was found, suggesting that whether or not the critical object is associated with the current (foregrounded/working) or previous (backgrounded) event model has no effect on accessibility for the target throughout the entire time-window. Furthermore, there was no difference in the rate of access for the target as time went on regardless of whether it was maintained in the foregrounded or backgrounded event model. However, an interaction was found between the Shifts and Foregrounding conditions, suggesting that across the entire time-window the target receives a larger proportion of fixations when no shift has occurred, but that this effect is driven primarily by cases in which the target is in the backgrounded event model, rather than the foregrounded event model. Finally, an interaction was found between the Shifts and Foregrounding conditions on the linear term, suggesting that as time goes on the rate of growth in fixations on the target is steeper when no shift has occurred if the target is in the foregrounded event model, rather than the backgrounded event model. Taken together, these results indicate that while there is no main effect of foregrounding on accessibility for the target, if no spatial shift has occurred the target is more accessible throughout the entire time-window in the backgrounded condition when compared to the foregrounded condition, but the rate of access for the target is quicker if no spatial shift has occurred in the foregrounded condition (vs. the backgrounded condition). These results are contrary to predictions from the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) and previous findings in the narrative comprehension literature (Glenberg et al., 1987; Whitney et al., 1992) which suggest that information in the working situation/event model should be more accessible than information outside of it, regardless of whether a spatial shift has occurred or not. The present results will be discussed in light of previous findings from experiments in this thesis, as well as previous work in the event comprehension literature (e.g. Radvansky, 2012; Rinck & Bower, 1995).

Supporting claims made by the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012), the present study showed that when a spatial shift has occurred, accessibility for the target object was reduced. In contrast to Experiment 2, this effect was found upon hearing the critical noun and not during the region prior to the referent. As discussed in Section 2.2.3, this may be driven by the predictability of potential referents; whereas in Experiment 2, the target object was always one of two previously mentioned objects in the visual scene, in the current study the target was always one of four potential targets that were mentioned in previous sentences. This suggests that, while a spatial shift can reduce accessibility for target objects, the time-course with which this occurs may be largely dictated by probabilistic constraints associated with the discourse structure; with a highly predictable discourse the effect of a spatial shift on object accessibility may occur during an earlier region of discourse processing. Crucially, and also in contrast to the findings of Experiments 1 and 2, the main effect of a spatial shift was found regardless of whether the target object was in the working (foregrounded) or backgrounded event model. While this does not rule out the possibility that the effects reported in Experiment 2 may be influenced by foregrounding, the results of the present study provide strong evidence for the effect of a spatial shift divorced from other factors. Although not an altogether unique finding, this stands in stark contrast to the results of Morrow et al. (1989, 1987) who failed to find any difference between locations that did not differ in foregrounding. Indeed, the only other study to show an effect of spatial shifts on accessibility for objects while controlling for foregrounding did so by collapsing across four experiments (with a total of 168 participants) (Rinck & Bower, 1995), suggesting that the present paradigm may be more sensitive to the effects of a spatial shift than traditional methods employed in the event model literature.

One particularly interesting finding from the present experiment in regards to spatial shifts is that when a shift occurs this reduces accessibility for target objects in the narrative even when this shift is made to a previously-mentioned location. While previous studies by Radvansky and colleagues (Radvansky & Copeland, 2006; Radvansky et al., 2011, 2010) have shown that a spatial shift reduces accessibility for a carried object, Experiment 3 by Radvansky et al. (2011) showed that this was driven only by cases in which a shift was made to a new location. The present results could reflect a number of possibilities: (1) that the number of shifts made to a new location by the protagonist is taken into account during discourse processing; (2) that the number of shifts to a new location does not matter during discourse processing, only the number of shifts made; (3) that shifts to new locations have larger effects than shifts to previously-encountered locations, but that both types of shift have an effect.

In regards to the first point, it is possible that during discourse processing comprehenders take the perspective of the protagonist (Brunyé, Mahoney, & Taylor, 2010), and that while they are made aware of several other locations within the narrative, their construction of separate event models is dictated by the experiences of the protagonist. Thus, in the present experiment, while listeners are made aware of each location in the initial sentences, they focus on the events, location, and movement of the character described in sentence 2, and as such shifts made to a new location by this character cause reduced accessibility for the target due to the need to construct a new event model from the perspective of the protagonist. This interpretation is plausible in regards to previous research, as in all map learning paradigms (e.g. Morrow et al., 1989, 1987; Rinck & Bower, 1995), participants are aware of all locations within the superordinate location, however effects of a spatial shift are found regardless. Thus, it is possible that in the current experiment because each location is unique to the second-mentioned character (i.e. the protagonist), that the effects of a spatial shift are found. However, this interpretation is incompatible with the lack of any main effect of foregrounding found here, and is also incompatible with the greater level of accessibility for the target in the No-shift condition when the object is in the backgrounded event model. According to past research (Borghi et al., 2004; Brunyé et al., 2010) and theory (Radvansky & Zacks, 2014), if comprehenders take the perspective of the protagonist during comprehension then objects in the same location as the protagonist should be more accessible than objects in a different location to the protagonist. Thus, another explanation must account for the observed effects in the present study.

In regards to the second point, while no current research in discourse processing has explored the role of shifts to previously-encountered locations vs. shifts to new locations, it is unlikely that – following research by Radvansky et al. (2011), and given the Event Horizon model's (Radvansky & Zacks, 2014; Radvansky, 2012) close link to research on situation models – shifts to new locations are perceived in and cause a similar effect as shifts to previously-encountered locations. Instead, we should expect only shifts to a new location, and not previously-encountered locations, to reduce the accessibility for the target. However, future research could seek to confirm whether or not this assumption is correct. A more interesting question, however, lies in the third point; upon closer inspection of probe-task reaction time and error rate data in Experiment 3 of Radvansky et al., it is clear that, while non-significant, there is a marked increase in errors and reaction times between the shift and shift-and-return conditions. With only 48 participants, it is plausible that similarly to Rinck & Bower (1995), Experiment 3 of Radvansky et al. may have lacked the sufficient power to detect any difference between these two conditions. In conjunction with the results of the present experiment, it is plausible that a spatial shift always causes a decrease in accessibility for information, but that this effect is stronger when this shift is made to a new location, necessitating the construction of a new event model (Radvansky & Zacks, 2011), which may be more costly than reactivating a previously-relevant event model.

While it was predicted that the target would be less accessible in the Shift condition when compared to the No-shift condition due to costs associated with the need to create a new event model or to update the working event model, it was also predicted that the target would be more accessible if it was maintained in the foregrounded location (i.e. the final location of the protagonist) rather than the backgrounded location, regardless of whether a spatial shift occurred or not. However, no main effect of foregrounding was found. Given the design of the current experiment, there are, however, several reasons for why no effect of foregrounding was found. Firstly, it is possible that because the narrative mentioned both locations in all conditions this drew comprehenders' attention to both locations. Adhering to the Gricean maxim of quantity (Grice, 1975), “Make your contribution as informative as is required…Do not make your contribution more informative than is required” (p. 45), it is possible that mentioning both locations made both locations equally relevant to the unfolding narrative and as such comprehenders maintained both locations at a similar level of accessibility (either in working memory or long-term memory). In doing so, this could have negated any effects of foregrounding in regards to greater accessibility for the target when in the same location as the protagonist. Moreover, introducing two characters that interact with both locations and objects may have resulted in comprehenders failing to take any one perspective during comprehension, and thus failing to foreground any one location over another. Finally, it is also possible that the first-mentioned character was made most relevant through primacy of mention and referring to the protagonist using possessives (e.g. ‘her sister’). This could have resulted in comprehenders instead focusing on the first-mentioned character (with an undefined spatial location), rather than the intended protagonist. In both cases, it is likely that the location of the protagonist was not the main focus of comprehenders (Wilson, Rinck, & McNamara, 1993) and as such was not maintained at a higher level of accessibility than the other location; the result of which is that no effect of foregrounding could be observed. However, regardless of the which perspective was taken during comprehension we likely observe an effect of a spatial shift due to the need to update the event model to accommodate a change in events.

Interestingly, an interaction was observed between the Shifts and Foregrounding factors, in which the target was more accessible in the No-shift condition if the target was in the backgrounded event model (i.e. a different location to the protagonist). However, over time the rate of access for the target was quicker in the No-shift condition if the target was in the foregrounded event model rather than the backgrounded event model. This suggests that there is an overall bias in terms of accessibility for the target in the No-shift condition when in the backgrounded event model, but that the target is easier to access in the No-shift condition when in the foregrounded event model (vs. the backgrounded event model). While the faster rate of access in the No-shift and foregrounded condition is unsurprising given the prediction that information in the foregrounded event model should be biased in terms of a higher level of accessibility, the fact that this only occurs as time goes on, and that throughout the entire time-window the target is more accessible in the No-shift and backgrounded condition (vs. No-shift and foregrounded condition) is rather surprising given the current literature on foregrounding. Indeed, this finding is contrary to the claims laid out by the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) and several findings from the narrative comprehension (Glenberg et al., 1987; Whitney et al., 1992) and event comprehension (Radvansky et al., 2011) literature. Through observing Figure 3.3, it is apparent that this could be driven primarily by differences in the proportion of fixations on the target around *y*-intercept at 200ms. At this point, for the No-shift condition the probability to fixate the target object is higher in backgrounded rather than the foregrounded case. Furthermore, observing Figure 3.2 it is clear that during the region prior to the target (i.e. ‘Then she will think about how…’) the target receives a disproportionately larger proportion of fixations in the No-shift and backgrounded condition than all other conditions (all ps<.001), but also the target receives a disproportionately lower proportion of fixations in the No-shift and foregrounded condition than all other conditions (all ps<.001). However, the two Shift conditions (foregrounded, backgrounded) receive a similar proportion of fixations between the foregrounded and backgrounded cases (p_1=.036; p_2=.319)[1]. On closer inspection of the items used in this study (see 6.2.Appendix C.1) it is apparent that while the two Shift conditions (foregrounded, backgrounded) counterbalanced the order of mention as displayed in Example 3.3:

Example 3.3. An example of the two Shift conditions (foregrounded, backgrounded)

> 1. The boy has put the skateboard and the key in the cafeteria, and the ball and the melon in the parlour.
>
> 2a. His sister will walk from the parlour to the cafeteria. (Shift, foregrounded)
>
> 2b. His sister will walk to the cafeteria from the parlour. (Shift, foregrounded)
>
> 2c. His sister will walk from the cafeteria to the parlour. (Shift, backgrounded)
>
> 2d. His sister will walk to the parlour from the cafeteria. (Shift, backgrounded)
>
> 3. Then she will think about how the skateboard is quite steady.

In the No-shift condition the order of mention was not counterbalanced across the foregrounded and backgrounded conditions, an example of which is displayed in Example 3.4:

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[1] For the purposes of this discussion, only *p*-values from models are provided. Model formulae are reported in 6.2.Appendix C.4.2, with *p*-values calculated using the `glht` function from the `multcomp` library.

Example 3.4. An example of the two No-shift conditions (foregrounded, backgrounded)

> 1. The boy has put the skateboard and the key in the cafeteria, and the ball and the melon in the parlour.
>
> 2a. His sister will walk around the cafeteria next to the parlour.
> (No-shift, foregrounded)
>
> 2b. His sister will walk around the parlour next to the cafeteria.
> (No-shift, backgrounded)
>
> 3. Then she will think about how the skateboard is quite steady.

In the two Shift conditions (i.e. Example 3.3), the location containing the target was equally likely to mentioned first or last in both the foregrounded (2a, 2b) and backgrounded cases (2c, 2d). However, in the two No-shift conditions (i.e. Example 3.4), the location containing the target was more likely to be mentioned first in the foregrounded condition (2a) and last in the backgrounded condition (2b). It is likely that in the No-shift and backgrounded condition, mentioning the location containing the target last resulted in the event model containing the target to become the working event model, and thus information in this model (including the target) became more accessible resulting in a bias in the probability to fixate on the target prior to mention, as depicted in Figure 3.1. Conversely, in the No-shift and foregrounded condition, mentioning the location containing the target first and a different location last likely prompted the last-mentioned location to become the working event model, in which information in this model becomes more accessible and information in separate models less accessible, resulting in a lower probability to fixate on the target throughout the entire time-window when compared to the No-shift and backgrounded condition. This suggests that recency of mention, rather than the final location of the protagonist, plays a large role in whichever event model becomes the working (foregrounded) event model prior to mention for the target. This is likely the case not only in the No-shift conditions, but also in the Shift conditions. In the Shift conditions, while half of the items represent foregrounding in the predicted direction (i.e. 2a in Example 3.3) such that the most recently mentioned location is also the location containing the protagonist and the target, half of the items that are intended to represent foregrounding (i.e. 2b in Example 3.3) likely also show an effect of recency of mention. As such, in the present experiment it is impossible to divorce recency of mention from any predicted effect of foregrounding driven by the location of the protagonist. In the Shift condition, no effect of foregrounding is likely found as all items were fully counterbalanced to control for the order of mention of each location. However, in the No-shift condition the target is likely more accessible in the backgrounded (vs. foregrounded) cases as the location containing the target was more recently mentioned in these items. The faster rate of access for the target in the No-shift condition in the foregrounded (vs. backgrounded) cases likely reflects comprehenders switching focus from the most recently mentioned (i.e. backgrounded) model to the model containing the target (i.e. the foregrounded model), with the faster rate of accessibility reflecting comprehenders ‘catching up’ or attempting to access the target following a switch in focus from one event model to the other. Thus, in the No-shift conditions (at least), it is likely that foregrounding for the working event model is mediated by recency of mention rather than the location of the protagonist, and that this recency of mention influences accessibility for the target.

In the Shift conditions, no main effect of foregrounding was found due to the items being balanced by recency of mention. It is possible that this counterbalancing could account for the lack of any effect of foregrounding in the Shift conditions: if foregrounding is influenced by recency of mention rather than the final location of the protagonist then it is unsurprising that because the foregrounded and backgrounded conditions mentioned the foregrounded and backgrounded locations an equal number of times as the first and most recently mentioned location then no effect of foregrounding would be found. Thus, in all cases in the present experiment it is likely that comprehenders do not take the perspective of the protagonist while understanding the narrative. However, an effect of a spatial shift by the protagonist is likely still found due to the need to update the event model, regardless of which perspective is taken during comprehension. Indeed, while comprehenders can take a first-perspective during the construction and use of an event model, this type of perspective-taking is not necessary (Brunyé et al., 2010). Moreover, using different types of perspective, such as a survey-type (e.g. birds-eye view) or route-type (e.g. humans-eye view) perspective in reading tasks has no influence on the makeup of the spatial mental model: In one experiment by Taylor and Tversky (1992), participants read layouts of a large area such as a town from a route perspective or a survey perspective. When given inference statements about the spatial relations within the memorised location, verification for these statements was equivalent regardless of the perspective taken. Thus, if knowledge of spatial relations is perspective-independent, it is likely that other factors – such as the need to update an event model to accommodate a change in location for one character (e.g. the protagonist in the present experiment) – act independently of whether or not comprehenders take the perspective of the character that undergoes a change in location. In the present experiment, a spatial shift likely reduced accessibility for the target object (vs. no spatial shift) due to an increase in processing costs associated with updating the event model (Radvansky & Zacks, 2011), regardless of whether or not comprehenders took the perspective of the protagonist during comprehension.

The present experiment aimed to explore the role of foregrounding and spatial shifts on object accessibility during discourse processing. In order to control for an imbalance in the number of locations mentioned in the narrative across the Shift and No-Shift conditions (such as in Experiments 1 & 2 of the present thesis), two locations containing two objects each were mentioned in both conditions. In order to establish that the protagonist did not move from the initial location in the No-shift condition, the structure of the discourse necessitated always mentioning the location of the protagonist (assumed to be the working model) as the first location, and the other location as the most recently mentioned location. While an alternative structure to the sentences could have only mentioned the location containing the protagonist in the No-shift condition, thus avoiding confounds with the location of the protagonist and recency of mention, this would involve an imbalance in the number of locations mentioned prior to re-mention of the target. In this case, it would be difficult to distinguish whether any difference in the No-shift and Shift conditions was attributed to the need to update the event model in the Shift condition (but not the No-shift condition), or the need to maintain more than one event model in memory in the Shift condition (vs. only one in the No-shift condition). While the present experiment has shown that a spatial shift reduces accessibility for the target regardless of whether or not the event model containing the target is the initially foregrounded or backgrounded event model, future experiments should attempt to establish whether foregrounding attributed to the location of the protagonist can affect accessibility for a target independently of a spatial shift. Building upon the current paradigm, future experiments should control for the recency of mention for each location in the No-shift conditions. It is likely that in the present experiment due to the narrative mentioning two characters, and referring to the protagonist using possessives, no one perspective was taken during comprehension, and as such the location of the protagonist did not guide which event model was the working event model, but instead foregrounding was guided by recency of mention. As such, future designs should attempt to ensure that comprehenders rely on the location of the protagonist when understanding the discourse to observe effects of foregrounding divorced from recency of mention.

Taken together, the current experiment has shown an effect of a spatial shift on object accessibility during discourse processing. It is likely that the effects of a spatial shift are observed regardless of whether or not this involves a shift to a location new to the protagonist (cf. Radvansky et al., 2011) given that the data indicates that comprehenders focus on the most recently mentioned location rather than tracking the location of the protagonist when establishing the working event model, however further explorations are required to confirm this assumption. However, what is important to note is that a spatial shift causes interference when accessing a target object during online discourse processing, and that, in the present experiment, this effect occurs independently of any effect of foregrounding (driven by recency of mention). This suggests that spatial shifts contribute to the allocation of attention and accessibility for objects during discourse processing independently of any effect of foregrounding (cf. Experiment 2 of the present thesis). Building upon the results of Experiment 2, the effect of a spatial shift on object accessibility has also been shown to arise even when no location is visually foregrounded. Indeed, the present experiment improved on the paradigm utilised in Experiments 1 and 2 by introducing both of the locations across conditions, removing any confound associated with a difference in the number of locations represented across conditions. As such, the findings of the present experiment have increased confidence in the conclusion from Experiment 2 that a spatial shift negatively influences object accessibility during discourse processing.

The effect of a spatial shift reported here is in line with previous findings in language comprehension (Morrow et al., 1989, 1987; Rinck & Bower, 1995; Rinck et al., 1997), virtual reality (Radvansky & Copeland, 2006), and real-world tasks (Radvansky et al., 2011), as well as claims laid out by EST (Radvansky & Zacks, 2011) and the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012). However, when interpreting these findings in light of the Event Horizon model, it is important to note the differences in the locus of the reported spatial shift effects reported here and elsewhere. In Experiment 2, in keeping with research by Bower, Rinck, and colleagues (e.g. Morrow et al., 1989, 1987; Rinck & Bower, 1995; Rinck et al., 1997), it is likely that, following EST (Radvansky & Zacks, 2011), objects become less accessible once a spatial shift has occurred as this leads to a transient increase in prediction error associated with model creation/transformation, leading to a global decrease in accessibility for information maintained in working memory. In these cases, when attempting to access the target, a spatial shift reduces accessibility for the target in a backgrounded event model (vs. no spatial shift) as attention must shift from the event model associated with the location of the protagonist to the event model containing the target. While the effect of a spatial shift is often weak when divorced from that of foregrounding (Rinck et al., 1998), the present experiment has shown evidence that during online language comprehension a shift alone is enough to impair access for a target, regardless of whether the target is in the working event model or not.

It is clear that a different mechanism is at play in which a spatial shift reduces accessibility for the target in the present experiment in comparison to those carried out by Radvansky and colleagues (Radvansky & Copeland, 2006; Radvansky et al., 2011). In the present experiment, a spatial shift by the protagonist likely reduces accessibility for the target due to the need to update the event model to accommodate a shift in location for the protagonist; a process thought to be costly in terms of processing load (Radvansky & Zacks, 2011; Speer et al., 2007). In the experiments carried out by Radvansky and colleagues, an object is less accessible during response-probe tasks if it has moved from one room to another, rather than within one room. In this case, crossing a doorway (i.e. an event boundary) is thought to associate the object with two event models, while moving the object within one room is thought to associate the object with only one event model. When accessing the object, interference is thought to occur if the object is associated with two event models due to competition between the two event models on access (Radvansky & Zacks, 2014; Radvansky, 2012). Thus, while the present experiment suggests that a spatial shift for the protagonist reduces accessibility for the target due to general processing costs associated with updating the model, those experiments by Radvansky and colleagues suggest that when a target is represented in more than one event model via a spatial shift, then the target is less accessible due to competition between events on access. While the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) argues that this interference occurs between the multiple event models associated with the target, currently it is unknown how this interference occurs; that is, does competition between the event models occur prior to accessing the target? Or, do the multiple instantiations of the object compete or interfere with one-another more so if they are maintained in separate event models? Chapter 4 aims to establish this mechanism of competition.

While a clear effect of a spatial shift was observed in the present experiment, no effect of foregrounding – a rather robust effect in the situation model literature (e.g. Glenberg et al., 1987) – was reported. As the design of the present experiment may have contributed to the lack of any foregrounding effect, Chapter 5 aims to explore how foregrounding can modulate accessibility for information during discourse processing while incorporating a number of improvements to the present experimental design. Experiment 4 (in Chapter 5) fully controls for recency of mention for each location in each condition, and instead asks how foregrounding can influence accessibility for a competitor, rather than a target. This second change was made under the assumption that foregrounding effects in terms of accessibility for the target may be relatively difficult to detect using eye-tracking in that after mention for the target, while the target may be more accessible initially when foregrounded, when backgrounded comprehenders are likely to switch focus from the working event model to the one containing the target: in effect, these foregrounding effects should be relatively transient. If, however, on mention for the target accessibility for a competitor is taken as a measure of foregrounding, it is more likely that these effects should persist throughout the entire time-window; under the assumptions of the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012), on mention for the target the event model containing the target becomes the working event model, if it wasn't already. In either case, objects in the same event (foregrounded) model as the target should be most accessible, but objects in a different event model should be less accessible, with this event model being unlikely to be accessed after mention for the target. By observing accessibility for a competitor when in the same or a different event model to the target, any effect of foregrounding is likely to be stronger and longer-lasting than afforded by the present experimental paradigm.

Chapter 4

Event Structure Influences on Accessibility for Multiple Object Instantiations

4.1. General Introduction

Chapter 3 discussed one experiment (Experiment 3) deigned to explore the individual contribution of foregrounding and spatial shifts on accessibility for a target object. The reported experiment showed that when a spatial shift occurs, in the form of a protagonist moving from one location to another, accessibility for the target object decreases. Crucially, the effect of a spatial shift was found to be independent of any effect of foregrounding; regardless of whether the protagonist moved to or from the location associated with the target object, the target object became less accessible. This result is in-keeping with real-world and virtual reality tasks run by Radvansky and colleagues (e.g. Radvansky & Copeland, 2006; Radvansky, Krawietz, & Tamplin, 2011): In a series of experiments participants were tasked with carrying an object from one table to another, either crossing a doorway or not along the path of movement. They found that, when given a response-probe task in which participants had to indicate whether or not they had encountered the carried object (i.e. responding 'yes' to blue-cube if the colour and object shape matched), they were slower and less accurate in their responses if they carried the object across a doorway (vs. not). Crucially, this series of experiments has shown that, when controlling for the foregrounding of the updated instantiation of an object (i.e. the representation of the object in the final location) through associating it with every experienced model, a spatial shift still has a negative consequence for accessibility for the object. Experiment 3 has similarly shown that the effect of a spatial shift can be isolated from that of foregrounding. However, the reason for the reduction in accessibility for the target object could be different across Experiment 3 and the series of experiments run by Radvansky and colleagues (e.g. Radvansky & Copeland, 2006; Radvansky et al., 2011).

In regards to Experiment 3, Event Segmentation Theory (Radvansky & Zacks, 2011; Zacks et al., 2009) and the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) can be used to explain why a shift in experienced or imagined space can reduce accessibility for objects. Once a spatial shift has occurred the current model (of the current location) can no longer be used to accurately predict upcoming events. Due to this increase in prediction error, a new model must be created to accommodate the new location and the new sequence of events encountered here (Radvansky & Zacks, 2011). This model creation process is thought to be costly, associated with an increase in working memory demands. Upon recall, it is plausible that following a spatial shift, this increase in working memory demands caused a reduction in accessibility for information maintained within any given event model. However, this explanation is very different to that provided by Radvansky and colleagues for their series of experiments (e.g. Radvansky & Copeland, 2006; Radvansky et al., 2011). In these experiments, in order for a spatial shift to occur, the protagonist carried an object from one room to another. In doing so, this object was then associated with more than one event model, in contrast to only being associated with one model in Experiment 3 of the current thesis. In Radvansky and colleagues' experiments (Radvansky & Copeland, 2006; Radvansky et al., 2011), and in further works outlining the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012), the reduction in accessibility for the (carried) target object was attributed primarily to the fact that it was associated with multiple event models; on recall, accessibility for the target object is said to be reduced by interference associated with competitive retrieval, but what is not clear however, is the mechanism of interference. Neither Event Segmentation Theory nor the Event Horizon model explicitly claims *what* competes during recall; do the two event models associated with the target object interfere with one another prior to accessing the target object, or do the two instantiations of the object (in the initial and final event model) actively interfere with one another during access? Moreover, it is plausible that neither mechanism is the primary factor for the reduction in accessibility following a spatial shift when an object is associated with multiple event models. Perhaps, similarly to Experiment 3, the need to maintain multiple event models in working memory may cause a general reduction in accessibility for the target object due to an increase in processing costs following a spatial shift.

One way to explore whether the mechanism of interference differs between Experiment 3 and those of Radvansky and colleagues (e.g. Radvansky & Copeland, 2006; Radvansky et al., 2011) is to observe where visual attention is allocated following a spatial shift, or not, when an object is associated with a single or multiple event model(s): When attempting to access an object that has undergone a change in location, which instantiation of the object is accessed? And does accessibility for either instantiation differ if a spatial shift has occurred, or not? One way to address these questions is to look at the literature on the link between eye movements and dynamic events. Exploring the link between visual attention and recall, Richardson and Spivey (2000) showed that participants often look towards empty regions of space associated with where a target object once resided when attempting to access information related to the target (a result discussed and replicated in Experiment 2 of the current thesis).

Expanding on this research, Hoover and Richardson (2008) have shown that when we attempt to retrieve information associated with a target we do not simply look towards locations associated with the target itself, but rather we look towards the locations associated with both the target and the piece of information that we are attempting to retrieve. To find this, Hoover and Richardson showed participants a series of animations depicting a creature that burrowed from one location to another. Periodically, the creature would appear at one location and provide a statement related to a fact or a fictional character. When retrieving the facts, participants fixated on the locations associated with the facts more often than other locations. Crucially, however, Kukona, Altmann, and Kamide (2014) highlight that, in Hoover and Richardson's study, participants also fixated on the other locations visited by the creature more so than unvisited locations even when these locations were not associated with the queried fact. This indicates that some trace associated with the creature remains at a visited location even when this location is not relevant to the fact, but that this is accessed along with the associated location; thus, we spatially index semantic information with objects, rather than locations.

Parallels can be drawn between the results of Hoover and Richardson (2008) and Altmann and Kamide (2009). In this study, participants viewed a visual scene depicting a room containing several objects. Amongst these objects were a glass of wine (on the floor) and a table. Participants viewed this visual scene before it was replaced by a blank-screen, and then heard sentences such as 'The woman will put the glass onto the table. Then she will pick up the bottle and pour the wine carefully into the glass.' Upon hearing 'the glass' participants fixated on the discourse-mediated (final) location of the glass (on the table) more often than the initial location of the glass (on the floor). Thus, similarly to Hoover and Richardson (2008), participants were able to update their representation of the target object, and fixated on this updated location when accessing the target. Also, during this same region, participants were not more likely to fixate on the initial location of the glass than the final location of the glass (table) in the visual scene. This discrepancy in accessibility for the initial locations across both studies by Hoover and Richardson (2008) and Altmann and Kamide (2009) provided the impetus for Kukona, Altmann, and Kamide (2014) to explore what is accessed, and what might compete, when multiple locations are associated with an object (i.e. source and goal). In this experiment, participants viewed a quadrant containing four containers and heard sentences such as 'The boy will pour the sweetcorn from the bowl into the jar, and he will pour the gravy from the pan into the jug', varying the initial and final locations of the sweetcorn (bowl, jar) and gravy (pan, jug). Following this, participants heard 'But first/And then, he will taste the sweetcorn/gravy.' When an object was mentioned, participants fixated on the goal location more often than the source location. However, participants also fixated on the source location more than the two locations associated with the unmentioned object. Together, these experiments have shown that we can maintain multiple instantiations of an object when the spatiotemporal representation of said object is updated. While the results of Kukona et al. (2014) show that competition can occur on access for the updated instantiation at the object level (i.e. between the two instantiations), a similar paradigm might provide a means to explore whether interference between multiple instantiations can occur at the event level.

The current series of experiments aims to explore the mechanism of interference exhibited when accessing an object associated with multiple event models. In order to do so, a similar paradigm to that of Altmann and Kamide (2009) will be employed. In the studies reported by Altmann and Kamide, an object was described as moving from one location to another, with interest focused upon which location participants fixate upon re-mention of the object. In doing so, this paradigm allows for inferences to be drawn about which instantiation of an object is accessed during language processing. This is also of interest in the current series of experiments. However, here, the main question lies in how visual attention is allocated to each location associated with the target object when the two representations are held in the same event model, or in two separate event models. The methodology used to achieve this includes displaying to participants a visual scene depicting two rooms (containing several objects) separated by a doorway. In two conditions, participants listen to narratives describing one object moving from one location to another. The critical manipulation here is whether this path of movement occurs within one room (Together condition), or from one room to another (Apart condition). In the former case, it is assumed that the two instantiations of the object, in the initial and final location, are maintained together in one event model. In the latter case, it is assumed that the two instantiations are maintained in two separate event models. This methodology not only allows for confirmation of the main effects of a shift reported in Experiment 3, but also allows for an exploration into a number of other issues associated with the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012). Namely, the current experiment will address two key principles of the Event Horizon model: (1) the superior accessibility of information in the working (foregrounded) event model, (2) retrieval interference when accessing information stored across multiple event models during competitive access. These two principles will be addressed in light of the proposal from EST, that active memory for information in the working event model is flushed when the model is updated (Swallow et al., 2009), and their implications towards accessibility for information maintained in an updated event model.

Recalling the different types of event model updating discussed in Chapter 1, the present series of experiments will compare model transformation – updating the location of an object within one event model (Together condition), with model creation – updating the location of an object to be contained in a new event model (Apart condition) (Radvansky & Zacks, 2011). To do so, the present series of experiments take the form of a visual world study with a 'look and listen' task. Here, participants viewed one of two visual scenes, such as those depicted in Figure 4.1, for a short preview.

Figure 4.1. Example visual scenes accompanying spoken sentences (e.g. Example 4.1) in Experiments 4 and 5: (a) Apart condition (left) and (b) Together condition (right)

Following this, regardless of which visual scene was shown participants heard sentences, such as those depicted in Example 4.1, describing a protagonist moving an object from one location to another before looking at a second object prior to picking up the moved object. In all items the auditory stimuli were identical across conditions.

Example 4.1. An example of the linguistic stimuli used in Experiments 4 and 5

(1) The woman will take the book to the table.

(2) Then she will study the picture and pick up the book.

Crucially, in the Apart condition (e.g. Figure 4.1a) the narrative necessitates movement of the object from one room to another, while in the Together condition (e.g. Figure 4.1b), the movement of the object occurs within one room. As such, in the Apart condition the two instantiations of the object (in the initial and final location) are assumed to be maintained in separate event models, while in the Together condition the two instantiations of the object are assumed to be maintained in the same event model.

The Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) and Event Segmentation Theory (Radvansky & Zacks, 2011) state that when an object moves from one location to another we must update our event model to accommodate this change in location. When this movement occurs within what might constitute one event model (e.g. one room in a house; the Together condition) it is predicted that we simply transform the current, working event model. Whereas if an object moves from what might constitute one event model to another (e.g. from one room to another within a house; the Apart condition) then we create a new event model to represent the new location and the object maintained within in. In both types of updating, when an object is described as moving from one location to another, the event model must be updated, the consequence of which is that the initial instantiation of the object (in the initial location) will become less accessible, and the more recent instantiation (in the final location) will become more accessible (Radvansky & Zacks, 2011; Swallow et al., 2009). While the Event Horizon model claims that interference occurs when accessing an object associated with multiple event models (Radvansky, 2012), it is not clear why this happens. Radvansky (2012) claims that when accessing a piece of information associated with multiple event models, these events models compete with one another, likely driven by a 'fan effect' (Radvansky, 1999); the more event models associated with an object, the harder it is to recall. What isn't clear is whether these multiple event models associated with the target object compete with one another, or actively interfere with one another during access for the target object.

When both instantiations of a moved object are maintained in separate event models (vs. together in one event model) (i.e. in the Apart condition), we might predict one of two mechanisms to be at play when attempting to access the updated instantiation of the object: (1) under the assumption that competition occurs before an event model is selected (and its contents reactivated) (henceforth *event competition*) we might predict (i) a decrease in accessibility primarily for the updated instantiation of the object (i.e. the goal; table), with little change in the accessibility for the initial instantiation of the object (i.e. the source; book), or (ii) a decrease in accessibility for both instantiations (e.g. book and table) due to the general processing costs associated with maintaining and selecting between multiple event models related to the target object. Thus, in terms of the predicted pattern of eye-movements in the present example set, if competition occurs in the Apart condition prior to accessing the target then we might predict that the goal (e.g. table) receives a lower proportion of fixations in the Apart condition (vs. Together condition), with no difference in the proportion of fixations on the source (e.g. book) across conditions. Or, instead we might predict that both locations receive a lower proportion of fixations in the Apart condition when compared to the Together condition. Essentially, both predictions assume that the need to select between two relevant event models prior to accessing the target causes conflict when accessing the target due to the need to select between two event models. What is not clear here is whether this conflict will only be isolated to reduced accessibility for the goal (i.e. in general comprehenders rarely access the source, so any difference between conditions is negligible), or whether this conflict is manifested in reduced accessibility for both instantiations of the object (i.e. the source and goal).

But, (2) under the assumption that, in the Apart condition, the two event models interfere during access (henceforth *event interference*), rather than before access, we might predict a decrease in accessibility for the updated instantiation of the object (e.g. table) due to an increase in accessibility for the initial instantiation of the object (e.g. book). In terms of the predicted pattern of eye-movements in the present example set, if interference occurs while accessing the target in the Apart condition then we might predict a lower proportion of fixations on the goal (e.g. table) in the Apart condition (vs. Together condition) but a larger proportion of fixations on the source (e.g. book) in the Apart condition (vs. Together condition). While the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) argues that interference occurs at the event model level, suggesting that an event model must be selected prior to accessing the target (i.e. in line with prediction (1)), prediction (2) finds support from recent brain imaging studies that have shown that when an object undergoes a distinct change in state, conflict associated brain areas are active (Hindy, Altmann, Kalenik, & Thompson-Schill, 2012); perhaps the mechanism of interference here could be driven by a similar sort of dissimilarity-based interference? That is, the more dissimilar the two instantiations of the object become through association with different event models, the more distinct these two instantiations are, and the more they interfere with one-another on access.

Together, the two explanations of the effect of maintaining multiple instantiations of an object in separate event models, and the theory and model they are based upon, focus on cases of event creation and neglect the case of event transformation. Assuming that the two instantiations of an object are maintained within one event model if they are both held in the same room (i.e. the Together condition), then the experiment by Altmann and Kamide (2009), whereby a glass is described as moving from the floor to a table, involves event transformation, with the instantiations of the object maintained in one event model. Observing their findings, Altmann and Kamide showed that while participants could access the updated instantiation of a moved object, the initial instantiation of the object was still highly accessible. Because information in the working event model tends to be more highly accessible than information outside of it, one final outcome could potentially arise: (3) it is possible that when the two instantiations of an object are maintained in one (working) event model (i.e. the Together condition) the two instantiations of the object are more accessible as no interference will occur, and because both instantiations of the object are maintained in the same event model, foregrounding will make both instantiations of the object highly accessible. As a result of this foregrounding effect, two outcomes are possible: (i) the two instantiations should be more accessible in general in the Together condition when compared to the Apart condition, or (ii) because the initial instantiation of the object is highly accessible in the Together condition through foregrounding, it should interfere with access for the final instantiation of the object, perhaps due to similarity-based interference (e.g. Gordon, Hendrick, & Johnson, 2001).

While the principles of the Event Horizon model do not make any strong claims as to how visual attention will be resolved when multiple instantiations of the same object are maintained in the same or separate event models, given the previous literature showing a general decrease in accessibility for information following a spatial shift by either the protagonist (Glenberg et al., 1987; Rinck et al., 1998, 1997; Rinck & Bower, 1995) or the protagonist and the probed-for object (Radvansky & Copeland, 2006; Radvansky et al., 2011), it is likely that, while several predictions (described earlier) could be plausible, either both instantiations of the object should be less accessible in the Apart condition (i.e. event competition), or the final instantiation should be less accessible in the Apart condition when compared to the Together condition due to interference from the initial instantiation (i.e. event interference). Crucially, using eye-tracking allows us to explore the mechanism of competition described by Radvansky (2012) due to the binary nature of fixations on any given location at any given time during language processing. Moreover, through using the same discourse, any effect of the surface structure of the language cannot differentially affect eye-movement behaviour across conditions. By using the current paradigm, the given series of experiments will explore not only whether a spatial shift reduces accessibility for the updated instantiation of a target object when controlling for foregrounding of the object across shift/no-shift cases, but how interference is manifested, at least in terms of visual attention, when the two instantiations of the moved object are maintained in the same or separate event models.

4.2. Experiment 4

4.2.1. Method

4.2.1.1. Participants

Thirty (9 male) native speakers of English from the University of Dundee community (aged 17-37, M = 20.37, SD= 4.25) took part in this study for partial course credit or for £3. All participants had uncorrected vision, wore soft contact lenses, or wore spectacles, and had no known auditory, visual, or language disorders.

4.2.1.2. Apparatus

The same apparatus used in Experiments 1 and 2 were used here. However, the nine-point calibration was carried out every 8th trial.

4.2.1.3. Materials

Twenty pairs of experimental pictures (see Figure 4.1), depicting 2 rooms containing several objects separated by a doorway, were paired with two sentences that correspond to those presented in Example 4.1. Crucially, in the Apart condition (e.g. Figure 4.1a) the narrative necessitates movement of the object from one room to another, while in the Together condition (e.g. Figure 4.1b), the movement of the object occurs within 1 room. As such, in the Apart condition the two instantiations of the object (in the initial and final location) are assumed to be maintained in separate event models, while in the Together condition the two instantiations of the object are assumed to be maintained in the same event model.

In the visual scenes, the distance between the source (e.g. book) and goal (e.g. table) was identical across pairs. The source object was always located in the centre of the visual scene, but varied in their vertical orientation. The direction of movement of the source was counterbalanced across items so that goals were equally likely to appear in each of the four corners of either room. The orientation of boundaries was also counterbalanced equally across items, with specific regard to the direction of movement of the source, such that the object moved across a left- and right-facing boundary an equal number of times across items. All items also contained another possible goal location (e.g. chair) in the same location as the source in the Apart condition, or in a different location in the Together condition, so that accurate prediction of where the source might move would not be possible. In an additional 20 filler items, the source was not located in the centre of the scene; instead it could be in any of the four locations associated with distractor objects in the experimental items. In half of the filler items the discourse-final noun did not refer to a moved object. Each (experimental and filler) item used unique protagonist nouns in the first sentence and unique verbs in the second sentence, also rotating across one of four movement verbs in the first sentence and one of four looking verbs in the second sentence. The combination of nouns and verbs was randomised. All objects used within all sentences and visual scenes were unique.

Two fully randomised lists were created for the experimental and filler items. Both lists were randomised per participant and had a run length of 2 for condition, so that only two items from the same condition (or 2 fillers) would be presented sequentially. Each list contained one version of the two sentential conditions corresponding to each of the twenty experimental items, as well as an additional twenty filler items. For a full list of the sentential stimuli used for recorded sentences, see Appendix D.1. For examples of all visual scenes, see Appendix D.2.

4.2.1.4. Procedure

A similar procedure to that used in Experiment 1 was used here. However, in this experiment, participants were presented with one of two visual scenes (Figure 4.1a or Figure 4.1b). Visual scenes and auditory stimuli were presented concurrently, in order to ensure that participants had visual information about the spatial relations among objects (e.g., book, doorway, table) when they were processing the linguistic discourse. Participants completed four practice trials at the beginning of the experiment, after which they had the opportunity to ask any questions prior to the continuation of testing. The practice trials consisted of 2 experimental-type items and 2 filler-type items. The experimental session consisted of 20 experimental and 20 filler items as outlined in Section 4.2.1.3. For all trials, each scene was programed to be displayed for a preview of 1000ms. From preview, the visual scene remained onscreen for the duration of the trial (average of 11,770ms). After the preview of the visual scene, the first sentence played; the second (critical) played 1000ms after the offset of the first sentence. Each individual trial was automatically terminated 4000ms after the offset of the final sentence. The average durations, onsets, and offsets for each region are presented in Table 4.1, taking into account variability with onsets as a result of the experimental program. The full testing session lasted approximately 25 minutes.

4.2.2. Results

Data were prepared and analysed using R version 2.15.0 (R Development Core Team, 2008), using the `lme4` package (version 1.0-5). A similar method of analysis used in Experiment 1 was used here, with the data down-sampled from a 500Hz temporal resolution so that fixations were reported every 10ms, aggregated across 50ms time bins. However, in this experiment the transformed proportion of fixations on the source (book) and goal (table) were analysed. Looks on each object were analysed separately, comparing differences between conditions. The time-course of this region was determined on a trial-by-trial basis (see Table 4.1 for mean durations). The transformed proportion of fixations on the source and goal were calculated starting from the onset of the first saccade towards the target, until the offset of the critical region within each (hand drawn) region of interest. Following Barr (2008), the region of analysis was determined at the earliest point at which eye movements to the source or goal were driven by the linguistic stimuli; this was at the onset of the critical noun (‘book’). The mean duration of fixations was calculated for each time window. Table 4.1 shows the average onset, offset, and duration for each region, taking into account variability with onsets as a result of the experimental program.

Table 4.1. Mean durations of temporal regions in the experimental sentences (ms) in Experiment 4

Label	Region	Onset	Offset	Duration
Sentence 1				
Start	‘The woman will take the book’	950	2920	1970
Preposition & determiner	‘to the’	2920	3250	330
Goal	‘table’	3250	3720	470
Sentence 2				
Start	‘Then she will’	4730	5370	640
Verb	‘study’	5370	5830	460
Determiner	‘the’	5830	5950	120
Distractor	‘picture’	5950	6570	620
Conjunction	‘and’	6570	6760	190
Verb phrase	‘pick up’	6760	7200	440
Determiner	‘the’	7200	7320	120
Target	‘book’	7320	7770	450

Empirical logit analyses (Barr, 2008) were conducted to analyse the average fixations (log odds scale) to the source (book) and goal (table) at the onset until the offset of the critical noun (‘book’). Separate analyses were run for the transformed data on each interest area. For each analysis, two models were created and run separately for by-participants and by-items analyses respectively, exploring whether association of the two locations of the book (on the floor or on the table) with the same or separate locations, and hence association of the two instantiations of the book with the same or separate event models, influenced fixations on each interest area.

4.2.2.1. Looks on the source (book) during the critical noun (‘book’)

Analyses of the transformed proportion of fixations on the source (book) were carried out during the critical noun region (‘book’). The average proportion of fixations on the source (book) across conditions is displayed in Figure 4.2 (with means and *SD* also reported in-text).

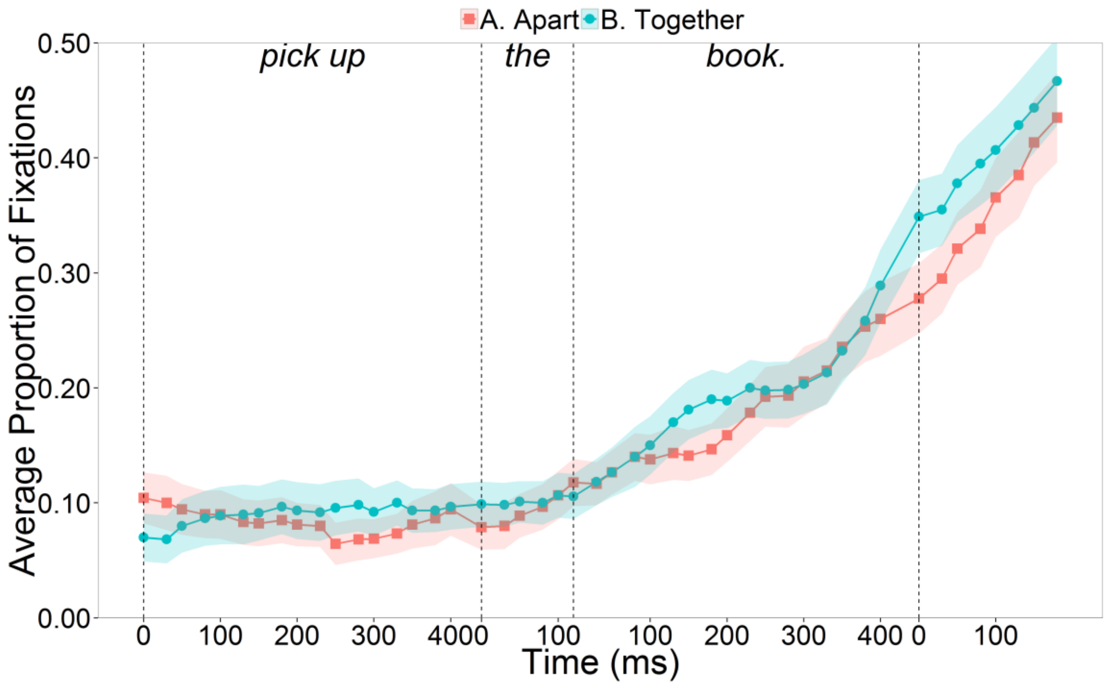


Figure 4.2. Average proportion of fixations on the source (book) by participants (N=30) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 4; shaded bands show standard error

Figure 4.2 shows the average proportion of fixations on the source by participants across conditions. At the onset until the offset of the critical noun region (‘book’) the source receives a numerically larger proportion of fixations in the Together condition (*M*=0.178, *SD*=0.138) than in the Apart condition (*M*=0.168, *SD*=0.136). The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below. When observing the transformed data for fixations on the source during the critical region of analysis, one point of inflection was identified (see Figure 4.3). As such, the main effect of condition (Together vs. Apart) was modelled as a fixed factor using orthogonal linear and quadratic polynomials (Mirman et al., 2008).

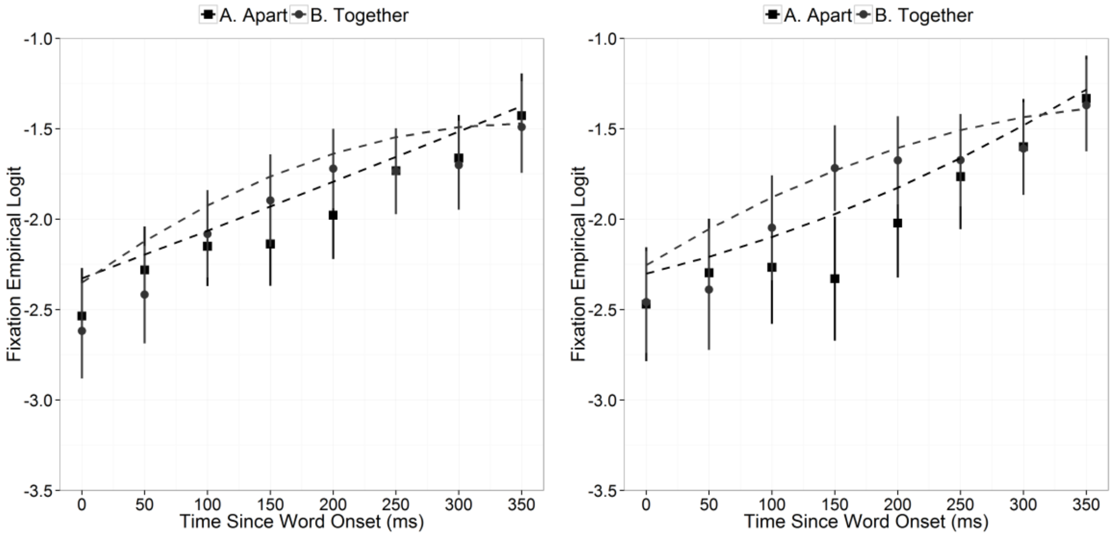


Figure 4.3. Model fits and fixations (transformed data) by participants (Left; N=30) and items (Right; N=20) on the source (book) during the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 4; point-ranges represent the empirical logit and their standard errors

In both by-participants and by-items models, dummy coding was used such that the Apart condition represented the baseline in each model. Due to a failure to converge using the maximal random effects structure, the correlations between random effects were removed. This method is suggested Barr, Levy, Scheepers, and Tily (2013) as the first step for simplifying random effects structure as it incurs the smallest increase in Type-I errors. However, both models contained random effects of participants and participants nested within condition on the intercept and slope terms for the by-participants analysis, and random effects of item and item nested within condition on the intercept and slope terms for the by-items analysis.

Both models contained fixed effects of the orthogonal linear and quadratic time terms and condition on the intercept and slopes. For full model examples, see Appendix D.3. For both models, statistical significance for individual parameter estimates was calculated using the normal approximation. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 4.2. In Table 4.2, as in other analyses on experiments using only two levels within a factor, a reference level within a factor is used as the baseline condition. In this case, the Apart condition is used as the baseline for the Intercept and two time-terms, such that the Intercept term represents the Apart condition's intercept, and the linear and quadratic terms represent the Apart condition's slope. The factor term – in this case the Together term – represents the Together condition's intercept relative to the Apart condition's intercept, and the two time terms crossed by the factor (e.g. Linear: Together, Quadratic: Together) represent the Together condition's slopes relative to the Apart condition's slopes. As noted in Section 2.2.2.2, only the intercept and linear terms will be interpreted here (and in Experiments 5 and 6), as these have the clearest cognitive implications (i.e. a difference in transformed fixations on an object across conditions represents an overall difference in accessibility for an object on the intercept term, and a difference in the rate of access for an object on the linear term). Thus, the Together term must be consulted in order to make inferences about the effect of condition on the proportion of fixations throughout the entire time-window, and the Linear: Together term must be consulted in order to make inferences about the differences in the slopes across the two conditions (i.e. on the linear term).

Table 4.2. By-participants [1] (N=30) and by-items [2] (N=20) parameter estimates for the transformed fixations on the source (book) at the onset until the offset of the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 4

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-1.856	0.071	-26.194	<.001***
Linear	0.885	0.088	10.033	<.001***
Quadratic	0.009	0.045	0.195	.846
Together	0.069	0.096	0.721	.471
Linear: Together	-0.067	0.108	-0.615	.538
Quadratic: Together	-0.236	0.061	-3.875	<.001***
By-items [2]				
Intercept	-1.855	0.065	-28.365	<.001***
Linear	0.935	0.077	12.174	<.001***
Quadratic	0.106	0.041	2.602	.009**
Together	0.123	0.092	1.332	.183
Linear: Together	-0.142	0.086	-1.644	.100
Quadratic: Together	-0.284	0.055	-5.199	<.001***

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 4.2 shows a non-reliable difference in terms of parameter estimates for the intercept and linear terms for the Apart vs. Together comparison (all ps >.05).

4.2.2.2. Looks on the goal (table) during the critical noun ('book')

Analyses of the transformed proportion of fixations on the goal (table) were carried out during the critical noun region ('book'). The average proportion of fixations on the goal (table) across conditions is displayed in Figure 4.4.

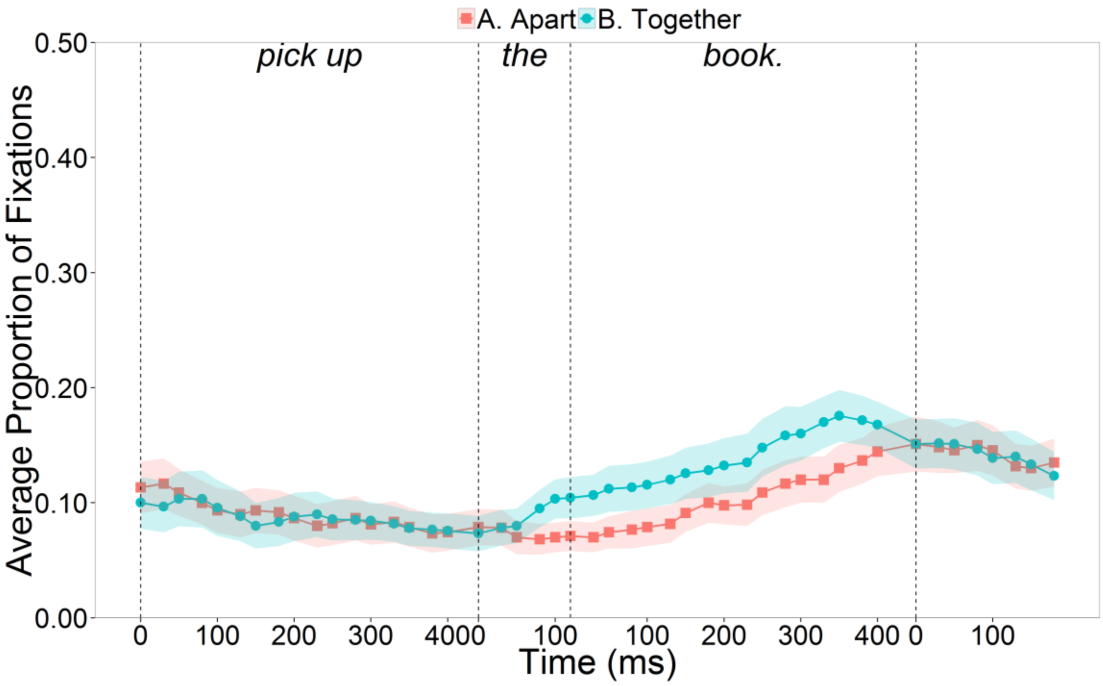


Figure 4.4. Average proportion of fixations on the goal (table) by participants (N=30) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 4; shaded bands show standard error

Figure 4.4 shows the average proportion of fixations on the goal by participants across conditions. At the onset until the offset of the critical noun region ('book') the goal receives a numerically larger proportion of fixations in the Together condition (*M*=0.136, *SD*=0.120) than in the Apart condition (*M*=0.098, *SD*=0.094). The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below. When observing the transformed data for fixations on the goal during the critical region of analysis, one point of inflection was identified (see Figure 4.5). As such, the main effect of condition (Together vs. Apart) was modelled as a fixed factor using orthogonal linear and quadratic polynomials (Mirman et al., 2008).

Similar models used in the analysis of the transformed data for fixations on the source (book) were used here. Specifically, time was modelled on the orthogonal quadratic term with fixed effects of condition (Apart vs. Together), and with random effects of participants/items and random effects of participants/items nested within condition on the intercept and slope terms. However, when including the correlation between the random effects, no convergence failures were reported; as such the correlation between random effects was included. For full model examples, see Appendix D.3. Plots of the transformed data and model fits are included in Figure 4.5.

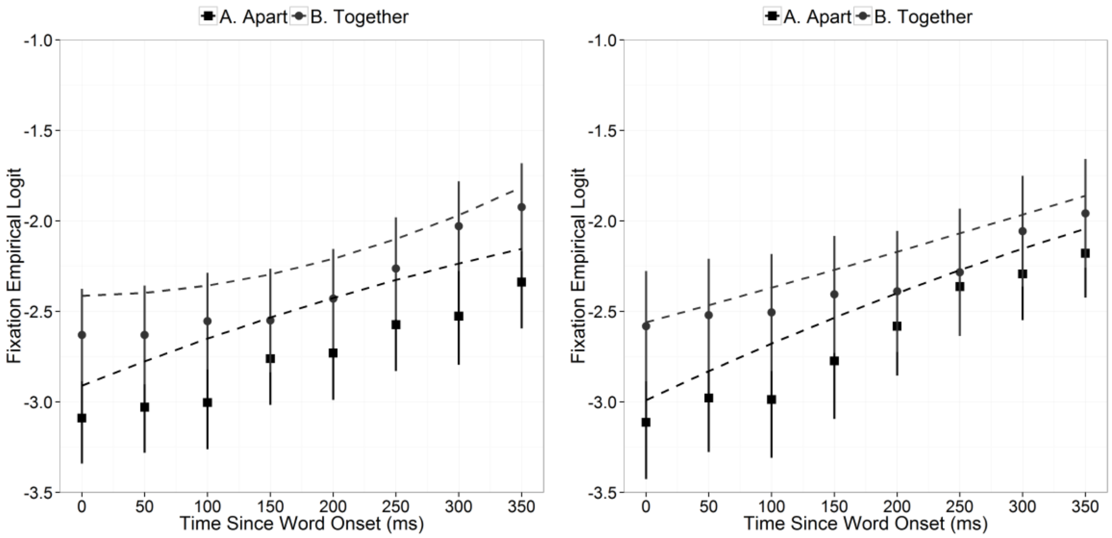


Figure 4.5. Model fits and fixations (transformed data) by participants (Left; N=30) and items (Right; N=20) on the goal (table) during the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 4; point-ranges represent the empirical logit and their standard errors

Statistical significance was calculated using the normal approximation. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 4.3. The Apart condition was the baseline for both analyses.

Table 4.3. By-participants [1] (N=30) and by-items [2] (N=20) parameter estimates for the transformed fixations on the goal (table) at the onset until the offset of the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 4

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-2.502	0.089	-28.162	<.001***
Linear	0.700	0.108	6.506	<.001***
Quadratic	-0.057	0.066	-0.871	.384
Together	0.307	0.078	3.954	<.001***
Linear: Together	-0.144	0.150	-0.957	.338
Quadratic: Together	0.206	0.089	2.307	.021*
By-items [2]				
Intercept	-2.488	0.087	-28.582	<.001***
Linear	0.877	0.085	10.310	<.001***
Quadratic	-0.055	0.050	-1.088	.277
Together	0.271	0.099	2.730	.006**
Linear: Together	-0.230	0.117	-1.964	$.050^{+}$
Quadratic: Together	0.065	0.069	0.943	.346

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 4.3 shows a non-reliable difference in terms of parameter estimates on the linear (p_1=.338; p_2=.05) term for the Apart vs. Together comparison. However, there is a significant difference between the two conditions on the intercept term (p_1<.001; p_2=.006) in the positive direction. This indicates that while there is no difference between the two conditions in the proportion of fixations on the goal as time goes on, throughout the entire time window the proportion of fixations on the goal (table) is larger in the Together condition than the Apart condition.

4.2.2.3. Looks on the boundary during the critical noun ('book')

One question that arises when observing no difference between conditions in terms of the proportion of (transformed) fixations on the source (book), but a lower proportion of fixations on the goal (table) in the Apart condition, is where else were participants looking in the Apart condition that could distract attention from the goal? One possibility is that due to the change in location of the boundary across conditions, participants could have fixated on this location differentially across conditions. To observe whether this was the case, analyses of the transformed proportion of fixations on the boundary were carried out during the critical noun region ('book'). The average proportion of fixations on the boundary across conditions is displayed in Figure 4.6.

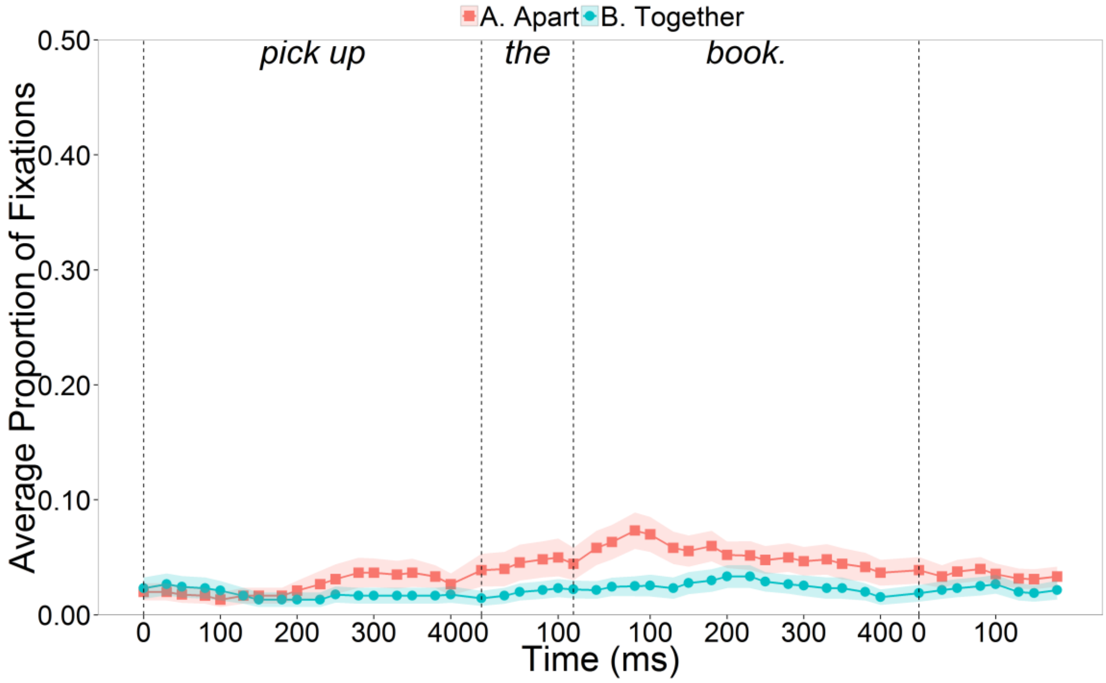


Figure 4.6. Average proportion of fixations on the boundary by participants (N=30) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 4; shaded bands show standard error

Figure 4.6 shows the average proportion of fixations on the boundary by participants across conditions. At the onset until the offset of the critical noun region ('book') the boundary receives a numerically larger proportion of fixations in the Apart condition (M=0.054, SD=0.072) than in the Together condition (M=0.026, SD=0.047). The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below. Similar models used in the analysis of the transformed data for fixations on the source (book) were used here. Specifically, time was modelled using orthogonal linear and quadratic polynomials, with fixed effects of condition (Apart vs. Together) and with random effects of participants/items and random effects of participants/items nested within condition on the intercept and slope terms. Similarly to the analysis for the transformed proportion of fixations on the source (book), due to a failure to converge using the maximal random effects structure, the correlations between random effects were removed (see Barr et al., 2013 for a discussion). For full model examples, see Appendix D.3. Plots of the transformed data and model fits are included in Figure 4.7.

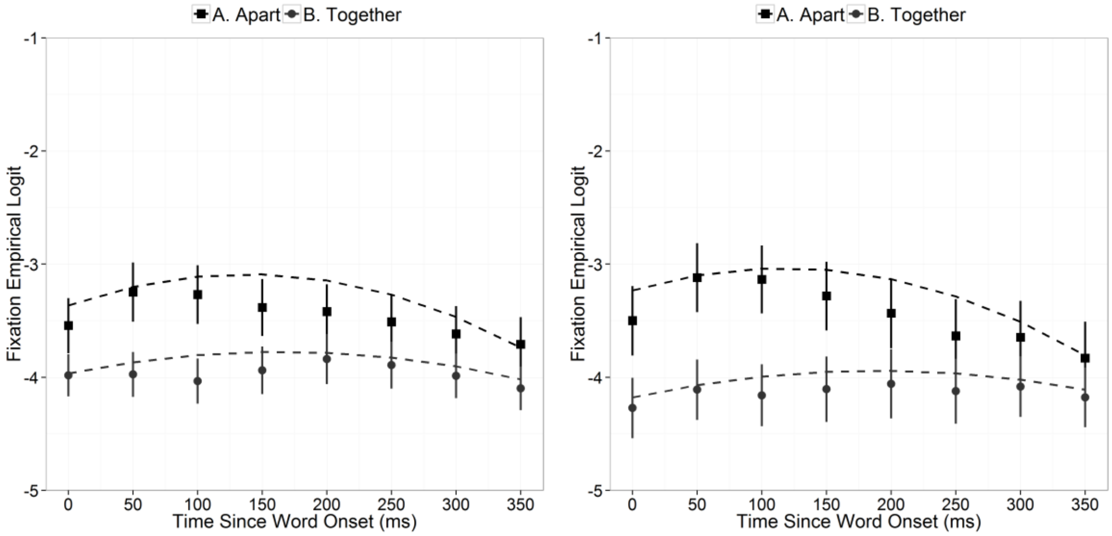


Figure 4.7. Model fits and fixations (transformed data) by participants (Left; N=30) and items (Right; N=20) on the boundary during the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 4; point-ranges represent the empirical logit and their standard errors

Statistical significance was calculated using the normal approximation. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 4.4. The Apart condition was the baseline for both analyses.

Table 4.4. By-participants [1] (N=30) and by-items [2] (N=20) parameter estimates for the transformed fixations on the boundary at the onset until the offset of the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 4

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-3.298	0.127	-25.889	<.001***
Linear	-0.346	0.202	-1.714	.087+
Quadratic	-0.467	0.116	-4.015	<.001***
Together	-0.570	0.178	-3.196	.001***
Linear: Together	0.297	0.220	1.352	.176
Quadratic: Together	0.239	0.149	1.601	.110
By-items [2]				
Intercept	-3.269	0.138	-23.724	<.001***
Linear	-0.531	0.174	-3.058	.002**
Quadratic	-0.462	0.127	-3.636	<.001***
Together	-0.761	0.185	-4.115	<.001***
Linear: Together	0.596	0.244	2.439	.015*
Quadratic: Together	0.249	0.180	1.386	.166

***p<.001; **p <.01; *p <.05; +.1< p<.05

Table 4.4 shows a non-reliable difference in terms of parameter estimates on the linear term for the Apart vs. Together comparison (p_1=.176; p_2=.015). However, there is a significant difference between the two conditions on the intercept term ($p_1 < .001$; $p_2 < .001$), with a larger proportion of fixations on the boundary in the Apart condition when compared to the Together condition. This indicates that while there is no difference between the two conditions in the proportion of fixations on the boundary as time goes on, throughout the entire time-window the proportion of fixations on the boundary is larger in the Apart condition than the Together condition.

4.2.3. Discussion

Experiment 4 explored two main issues: when controlling for foregrounding, does a spatial shift reduce accessibility for the updated instantiation of the object? Further, and more crucially, how is interference manifested when the two instantiations of an object are maintained in two separate event models (vs. one event model)? This experiment showed that when a spatial shift has been encountered, i.e. when the two instantiations of the object are held in separate event models (Apart condition), the goal location – associated with the updated instantiation of the object – is less accessible throughout the entire time window (i.e. on the intercept term) only. Observing these results in light of accessibility for the source location, there was no difference in the proportion of fixations on the source location on the intercept and linear terms. Finally, the boundary received a larger proportion of fixations in the Apart condition when compared to the Together condition throughout the entire time window (i.e. on the intercept term) only. While the current experimental results support the findings from Experiment 3, which showed that the target object becomes less accessible if a spatial shift has occurred regardless of whether it is foregrounded or not, this effect seems to be isolated to the updated instantiation of the object only.

Focusing primarily upon the proportion of fixations on both the source and goal locations on the intercept term, the current findings can be taken to support an account of event competition. One prediction for an event competition account is that only the goal location (i.e. the updated instantiation of the object) is less accessible on access for the target when maintained in multiple (i.e. Apart condition) (vs. one; i.e. Together condition) event model due to competition between the two event models prior to selecting, and accessing, the correct (updated) instantiation of the object (i.e. in the goal location). In the present experiment, this competition is manifested by reduced accessibility for the updated instantiation of the object (i.e. the goal) only, potentially due to increased processing costs associated with maintaining and selecting between two relevant event models. This thereby supports an event competition account, rather than an event interference account (which would suggest reduced accessibility for the goal due to increased accessibility for the source in the Apart condition when compared to the Together condition), potentially providing evidence of event-based rather than object-based (c.f. Kukona et al., 2014) competition during language processing. However, given the current paradigm, caution must be applied when interpreting the above findings to provide unequivocal support for an event competition account.

One caveat with attempting to distinguish between an event interference or event competition account in the current experiment is that fixations on the source may have been guided primarily by low-level referential processing, i.e. looking at the book upon hearing ‘book’; by using a co-present visual scene, it is likely that any differences in the proportion of fixations on the source object (book) guided by differences in the conditions may have been masked by such a mechanism. Specifically, observing the proportion of fixations on each location associated with the target (Figure 4.3, source; Figure 4.4, goal) there is a numerically larger proportion of fixations on the source object than the goal object, similarly to that found upon re-mention of a moved object in the concurrent viewing and listening task used by Altmann and Kamide (2009). However, this observation does not fit with the principles of Event Segmentation Theory (Radvansky & Zacks, 2011) and the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012), which state that information relevant prior to updating should become less accessible following a movement event. Given that the discourse also guides participants to access the updated instantiation of the object (i.e. in the goal location) it is likely that any fixations on the source may not be wholly guided by the event model, but rather by the low-level referential processing mechanism described above. As such, this could mask any potential difference in the proportion of fixations on the source location that could be guided by the event model. Here, then, it is possible that accessibility for the initial instantiation of the object (i.e. the source) could differ across conditions, thus changing interpretations for the precise mechanism of interference during competitive access for an object.

Moreover, while the goal location received a lower proportion of fixations in the Apart condition than the Together condition throughout the entire time-window, it is unclear whether this was driven by processing costs associated with maintaining multiple instantiations of the object in multiple event models, or by differences in the visual scenes across conditions. Given that the boundary received a larger proportion of fixations in the Apart condition than the Together condition, this could explain the difference in the proportion of fixations on the goal location across conditions. The question that this raises, then, is why does the boundary receive a larger proportion of fixations in the Apart condition when compared to the Together condition? One explanation is that during comprehension participants not only constructed a representation for the locations of objects but constructed a rich simulation of the events described in the language (Barsalou, 1999; Beveridge & Pickering, 2013); in particular, the movement of the protagonist. In the mental imagery literature, it has been shown that the time taken to access two points of a map increases as the distance between the two points also increases (Kosslyn et al., 1978). More recently, Lindsay et al. (2013) have shown that, in the visual-world paradigm, using action verbs implying fast (‘dash’) or slow (‘dawdle’) movement of a protagonist along a path to a goal, eye-movements reflect the described state of events: When hearing slow action verbs, participants looked more often at the path to a goal, whereas when using fast action verbs participants looked more often on the goal, and less often on the path. Given these findings, if participants have a rich representation of the described events in the current study, it is likely that in the Apart condition participants might have simulated the action of opening and walking through the door in order for the protagonist to move the book to the table. This could both increase the duration or complexity of events in the Apart condition (cf. Coll-Florit & Gennari, 2011) when compared to the Together condition (where this action is not necessary), causing participants to fixate on the door more often due to it becoming a more salient visual referent for the narrative boundary (cf. Tatler, Hayhoe, Land, & Ballard, 2011).

While simulating the movement of the protagonist from the source to the goal location may take longer (or require a more complex sequence of actions) in the Apart condition (vs. the Together condition), guiding more fixations on the boundary at a cost to fixations on the goal in the Apart condition (vs. the Together condition), it seems unlikely that this action would be simulated upon mention of the critical noun. Indeed, at this point, there is a large time-gap between this action and the mention of the critical noun. Instead, the increased proportion of fixations on the boundary in the Apart condition (vs. the Together condition) could represent a simulation of the protagonist moving towards the initial (incorrect) location. If so, it becomes difficult to distinguish between whether the current findings support an event competition or event interference account. That is, if the larger proportion of transformed fixations on the boundary throughout the entire time-window in the Apart condition (vs. the Together condition) reflects participants simulating the protagonist moving towards the incorrect location (and instantiation) of the object more so in this condition, then such results could reflect that this location (and instantiation of the object) actively interferes with access for the correct location (and instantiation of the object). Yet, surely this would also be accompanied by an increase in the proportion of fixations on the source location. Instead, it seems most likely that, in the present experiment, any differences in the proportion of fixations on the boundary are driven by low-level differences in visual saliency for the boundary across conditions.

Other alternative explanations for the difference in the proportion of fixations on the boundary across conditions lie in the differences in visual saliency of the boundary across conditions. Because the eyes must move across the doorway in the Apart condition in order to make any saccades to and from the source and goal locations, it is possible that this might increase fixations on the intervening boundary, making this location more visually salient and thus attract more fixations when compared to the Together condition (for a discussion on salience, see Fecteau & Munoz, 2006). Most notably, given that the current experiment did not have any overt task (aside from ‘look and listen’), the allocation of fixations within the visual scene are likely to be more heavily affected by the saliency of the visual scene than if a task was given to participants (Parkhurst, Law, & Niebur, 2002). This could inevitably come at a cost to fixations on the goal (table) location when processing the name of the target object in the Apart condition (vs. Together condition). Another consideration, given that the boundary is located spatially close in proximity to the source object, is that this proximity may cause the boundary to interfere with the allocation of attention to the source object, guiding fixations on the boundary instead of the source, either through interference (Driver & Baylis, 1989; Eriksen & Eriksen, 1974), or through the misallocation of fixations on the source object. Furthermore, fixations on the boundary may reflect slower/more difficult processing of the discourse in the Apart condition (vs. the Together condition), with visual attention simply remaining in the centre of the visual scene while attempting to retrieve the object on mention.

Finally, it is possible that the difference in the transformed proportion of fixations on the boundary do not reflect any differences in the complexity and/or time taken in simulating the actions of the protagonist, differences in visual saliency, and/or differences in processing differences across conditions, but rather reflects the notion that the interest areas for the boundary are more centrally located in the Apart condition (vs. the Together condition), thus counting more fixations on the boundary in this condition driven by a central fixation bias (Tatler, 2007) or due to a viewing strategy in which participants fixate on the location between the moved object prior to re-mention of the object. However, distinguishing between these accounts is impossible given the current paradigm. As such, the issues associated with the co-presence of the source object and differences in the location and visual saliency of the boundary between the two conditions might act to mask any potential differences between the two conditions as a result of differences in event structure. Thus, while the present findings can be taken to support an account of event competition, it is crucial to remove any visual bias which might differ across conditions for the proportion of fixations on the source location and the boundary driven by the co-present visual scene. As such, Experiment 5 replaces the visual scene with a blank-screen prior to the onset of the spoken discourse such that fixations on, and accessibility for both locations (and instantiations) of the object would be driven primarily by the event model, and not by differences in the visual saliency of scene across conditions.

4.3. Experiment 5

4.3.1. Introduction

While Experiment 4 showed a lower proportion of fixations on the goal object in the Apart condition when compared to the Together condition throughout the entire time-window, this was also associated with a larger proportion of fixations on the boundary in the Apart condition (vs. the Together condition) throughout the entire time-window. Moreover, there was no difference in the proportion of fixations on the source location throughout the entire time-window between the two conditions; however, the rate of increase in the proportion of fixations on the source was faster in the Together condition than the Apart condition. This suggests that while the initial instantiation of the object is equally accessible across conditions, it is accessed more rapidly in the Together condition than the Apart condition. But, because the target object was visually depicted in the initial location while listening to the discourse, it is likely that any differences in accessibility for the initial instantiation of the object (i.e. the source) may have been masked by low-level referential processing (i.e. looking at the book on hearing ‘book’). As such, it is unclear whether the fixations on the source object are guided by an attempt to access the instantiation of the object in the initial location from the event model, or by indexing between the word and its matching visual referent. While the lower proportion of fixations on the goal throughout the entire time-window in the Apart condition (vs. the Together condition) might suggest that the updated instantiation of the target is less accessible in the Apart condition (vs. Together condition), understanding how accessibility for the initial instantiation of the object differs (or doesn’t differ) across conditions is an important factor in determining the mechanism of interference when accessing an object associated with an event shift. Concluding whether the current findings reflect event competition, i.e. reduced accessibility for either both the initial and final instantiation of the object or reduced accessibility the final instantiation only, or other mechanisms discussed in Section 4.1 is thus dependent upon being able to make more accurate inferences about what drives visual attention towards the source.

Presently, it is difficult to interpret whether fixations on the source are driven by accessibility for the initial instantiation of the object, by low-level referential processing, or differences in the visual scenes (i.e. the location of the boundary) across conditions. Indeed, in the Apart condition, the boundary was positioned between the source and goal locations, whereas it was to the side of the source and goal in the

Together condition. It is possible that differences in the visual saliency of the boundary, or even differences in the estimated duration (or complexity) of events (Coll-Florit & Gennari, 2011) may have guided fixations on the boundary at a cost to fixations on the goal in Experiment 4, with this first factor potentially being the largest confound in Experiment 4. Under the first explanation, any differences in the proportion of fixations on any of the objects within the visual scene may be guided purely by differences in the visual scenes. Under the second assumption, any differences in the proportion of fixations on any of the objects within the visual scene may be guided by differences in the simulation of events *informed* by differences in the visual scenes. Moreover, it is also possible, but perhaps less plausible, that the source and boundary were paired in terms of spatial grouping across both conditions (Duncan, 1984), but that fixations on the boundary reflected misallocated fixations intended for the source object, or even ‘good enough’ fixations on the area associated with the source object in order to parafoveally process the source object. Under these assumptions then, the present results could (very tentatively) be said to support an event interference account. Yet, given the current results, Experiment 4 can only presently support an event competition account, that the final instantiation of the object is less accessible when the two instantiations are associated with separate event models, but with the caveat that several confounding factors may be at play – ones that could potentially explain these effects in light of a different mechanism of interference.

Given the aforementioned interpretations for the results of Experiment 4, Experiment 5 aims to reduce any visual bias in fixating any of the locations in the visual scene by replacing the visual scene with a blank-screen before the onset of the discourse (i.e. using the blank-screen paradigm; see Altmann, 2004). Not only will this control for differences in the visual scene on listening to the discourse, but it should allow for easier updating of the event model without a conflicting source of information representing the pre- and post-updating version of the locations and the objects represented in the visual scene. In doing so, it is expected that the current experiment will help to differentiate between several of the explanations of the results of Experiment 4.

4.3.2. Method

4.3.2.1. Participants

Forty (7 male) native English speakers from the University of Dundee (aged 17-40, *M* =19.85, *SD*= 3.99) took part in this study for partial course credit or for £3. All participants had normal or corrected to normal vision, and had no known auditory, visual, or language disorders. No participants in this study had previously taken part in Experiment 4 of the present thesis.

4.3.2.2. Apparatus

The same apparatus used in Experiments 1, 2, and 4 were used here, using a 9-point calibration every 8th trial.

4.3.2.3. Materials

The same materials that were used in Experiment 4 were used here.

4.3.2.4. Procedure

A similar procedure to that used in Experiment 4 was used here. However, unlike Experiment 4, each visual scene was replaced by a blank-screen prior to the onset of auditory stimuli. This blank-screen paradigm (Altmann, 2004) was used to remove low-level referential processing of the concurrently presented visual stimuli (i.e. looking at the book when hearing 'book'), particularly for the source (book), and to remove the visually salient boundary between the two locations while comprehenders processed the discourse.

For all trials, each visual scene was programmed to be presented for 6000ms before being replaced by a blank screen for the remaining duration of the trial (average of 17,870ms), however due to experiment error the average preview was 6050ms. After a 1000ms preview of the blank screen, the first sentence played. The second (critical) sentence was programed to be played 1000ms after the offset of the first sentence, but played 10ms after this. Each individual trial was automatically terminated 4000ms after the offset of the final sentence. The average durations, onsets, and offsets for each region are presented in Table 4.5. The full testing session lasted approximately 30 minutes.

4.3.3. Results

Data were prepared and analysed using R version 2.15.0 (R Development Core Team, 2008), using the `lme4` package (version 1.0-5). A similar method of analysis used in Experiment 4 was used here, specifically analysing the transformed proportion of fixations across conditions first on the source (book), then on the goal (table), and finally on the boundary. The time-course of the region of analysis was determined on a trial-by-trial basis (see Table 4.5 for mean durations). The transformed proportion of fixations on the source, goal, and boundary were calculated starting from the onset of the first saccade towards the target, until the offset of the critical region within each (hand drawn) region of interest. Following Barr (2008), the region of analysis was determined at the earliest point at which eye movements to each location were driven by the linguistic stimuli; this was at the onset of the critical noun ('book'). The mean duration of fixations was calculated for each time window. Table 4.5 shows the average onset, offset, and duration for each region, taking into account variability with onsets as a result of the experimental program.

Table 4.5. Mean durations of temporal regions in the experimental sentences (ms) in Experiment 5

Label	Region	Onset	Offset	Duration
Sentence 1				
Start	'The woman will take the book'	7050	9020	1970
Preposition & determiner	'to the'	9020	9350	330
Goal	'table'	9350	9820	470
Sentence 2				
Start	'Then she will'	10830	11470	640
Verb	'study'	11470	11930	460
Determiner	'the'	11930	12050	120
Distractor	'picture'	12050	12670	620
Conjunction	'and'	12670	12860	190
Verb phrase	'pick up'	12860	13310	450
Determiner	'the'	13310	13420	110
Target	'book'	13420	13870	450

Empirical logit analyses (Barr, 2008) were conducted to analyse the average fixations (log odds scale) to the source (book), goal (table), and boundary at the onset until the offset of the critical noun ('book'). Separate analyses were run for the transformed data on each interest area. For each analysis, two models were created and run separately for by-participants and by-items analyses respectively, exploring whether association of the two locations of the book (on the floor or on the table) with the same or separate locations, and hence association of the two instantiations of the book with the same or separate event models, influenced fixations on each interest area.

4.3.3.1. Looks on the source (book) during the critical noun ('book')

Analyses of the transformed proportion of fixations on the source (book) were carried out during the critical noun region ('book'). The average proportion of fixations on the source (book) across conditions is displayed in Figure 4.8.

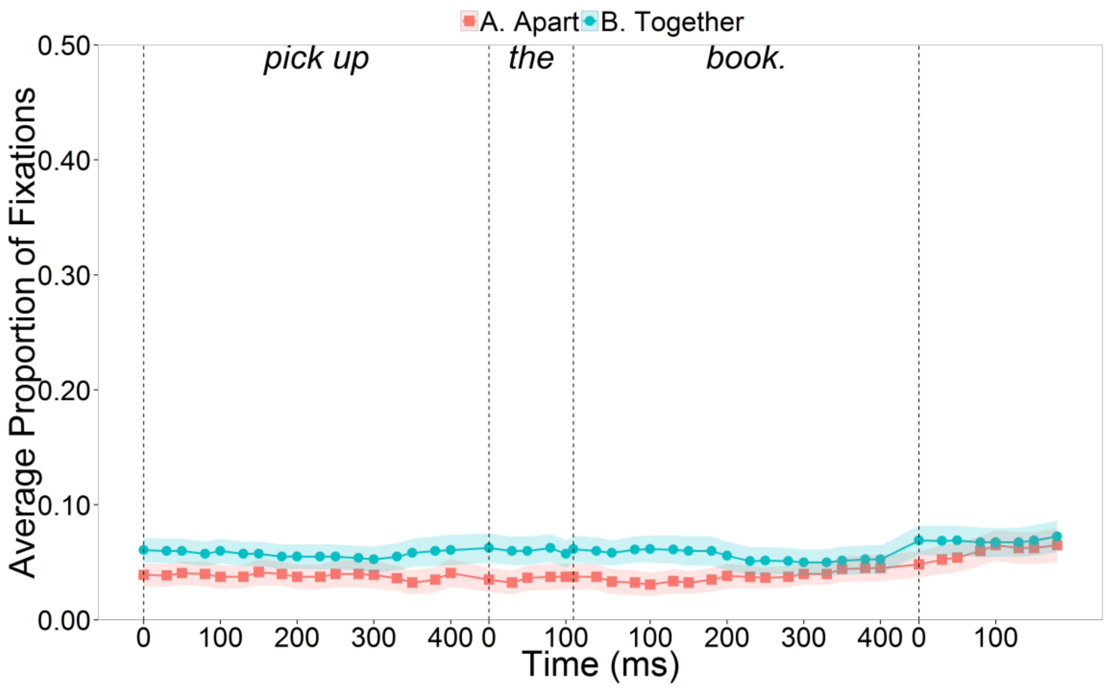


Figure 4.8. Average proportion of fixations on the source (book) by participants (N=40) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 5; shaded bands show standard error

Figure 4.8 shows the average proportion of fixations on the source by participants across conditions. At the onset until the offset of the critical noun region ('book') the source receives a numerically larger proportion of fixations in the Together condition (M=0.056, SD=0.074) than in the Apart condition (M=0.037, SD=0.064). The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below. When observing the transformed data for fixations on the source during the critical region of analysis, one point of inflection was identified (see Figure 4.9). As such, the main effect of condition (Together vs. Apart) was modelled as a fixed factor using orthogonal linear and quadratic polynomials (Mirman et al., 2008).

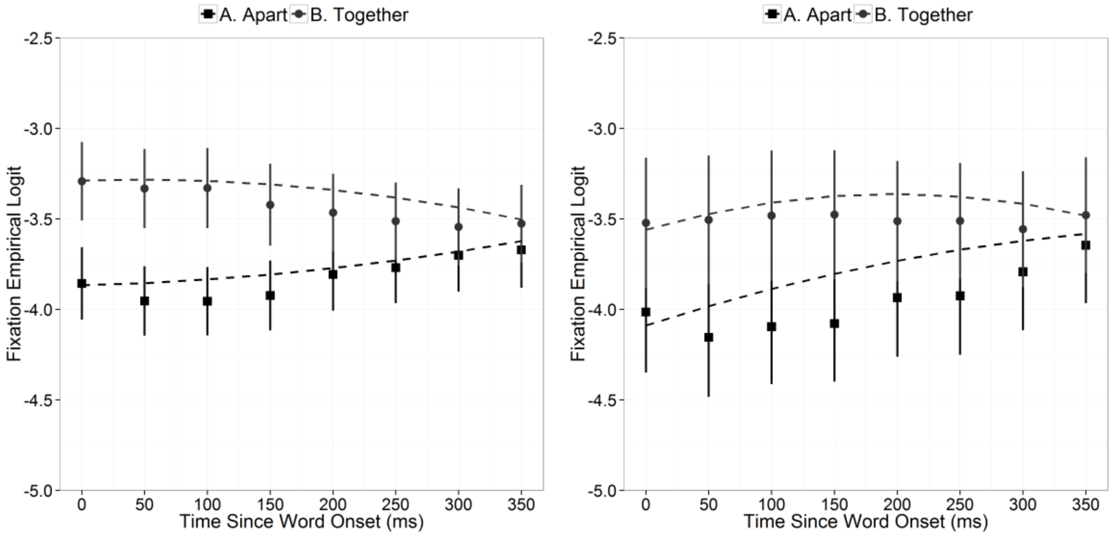


Figure 4.9. Model fits and fixations (transformed data) by participants (Left; N=40) and items (Right; N=20) on the source (book) during the critical noun region (‘book’) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 5; point-ranges represent the empirical logit and their standard errors

In both by-participants and by-items models, dummy coding was used such that the Apart condition represented the baseline in each model. Similarly to the analysis for transformed fixations on the source object in Experiment 4, due to a failure to converge using the maximal random effects structure, the correlations between random effects were removed (see Barr et al., 2013 for a discussion). Both models contained random effects of participants and participants nested within condition on the intercept and slope terms for the by-participants analysis, and random effects of item and item nested within condition on the intercept and slope terms for the by-items analysis. Both models also contained fixed effects of the orthogonal linear and quadratic time terms and condition on the intercept and slopes. For full model examples, see Appendix D.3. For both models, statistical significance for individual parameter estimates was calculated using the normal approximation. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 4.6.

Table 4.6. By-participants [1] (N=40) and by-items [2] (N=20) parameter estimates for the transformed fixations on the source (book) at the onset until the offset of the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 5

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-3.771	0.123	-30.586	<.001***
Linear	0.226	0.123	1.834	.067^{+}
Quadratic	0.049	0.063	0.782	.434
Together	0.417	0.119	3.493	.001**
Linear: Together	-0.424	0.167	-2.539	.011*
Quadratic: Together	-0.126	0.084	-1.490	.136
By-items [2]				
Intercept	-3.796	0.136	-27.822	<.001***
Linear	0.470	0.146	3.209	.001**
Quadratic	-0.074	0.044	-1.683	.092^{+}
Together	0.364	0.147	2.483	.013*
Linear: Together	-0.398	0.178	-2.230	.026*
Quadratic: Together	-0.091	0.060	-1.527	.127

****p*<.001; ***p* <.01; **p* <.05; $^{+}$.1< *p*<.05

Table 4.6 shows a significant difference on the intercept term for the Apart vs. Together comparison, with a larger proportion of (transformed) fixations on the source object in the Together condition when compared to the Apart condition (p_1=.001; p_2=.013). There is also a significant difference on the linear term for the Apart vs. Together comparison, with fixations increasing over time more rapidly in the Apart condition when compared to the Together condition (p_1=.011; p_2=.026). Taken together, this suggests that while the source is fixated on more often – and thus generally more accessible throughout the entire time-window – in the Together condition when compared to the Apart condition, the rate of access for the source is faster in the Apart condition when compared to the Together condition.

4.3.3.2. Looks on the goal (table) during the critical noun ('book')

Analyses of the transformed proportion of fixations on the goal (table) were carried out during the critical noun region ('book'). The average proportion of fixations on the goal (table) across conditions is displayed in Figure 4.10.

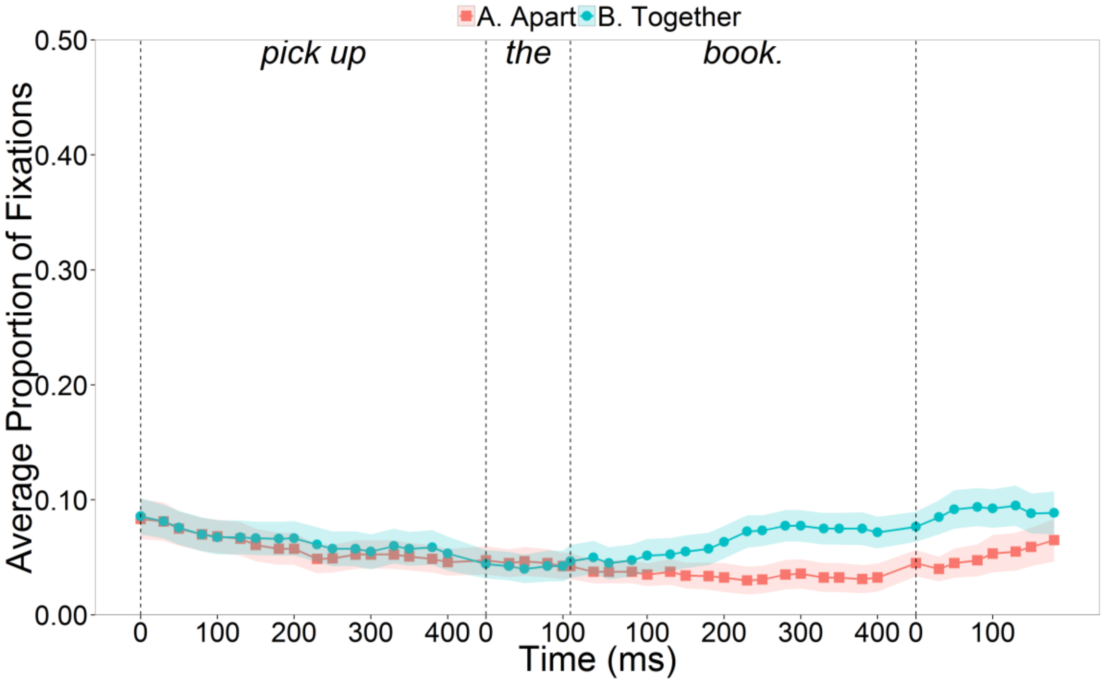


Figure 4.10. Average proportion of fixations on the goal (table) by participants (N=40) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 5; shaded bands show standard error

Figure 4.10 shows the average proportion of fixations on the goal by participants across conditions. At the onset until the offset of the critical noun region (‘book’) the goal receives a numerically larger proportion of fixations in the Together condition (*M*=0.062, *SD*=0.087) than in the Apart condition (*M*=0.035, *SD*=0.072). The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below. The same models used in the analysis of the transformed data for fixations on goal (table) in Experiment 4 were used here. Specifically, time was modelled on the orthogonal linear and quadratic terms with fixed effects of condition (Apart vs. Together), and with random effects of participants/items and participants/items nested within condition on the intercept and slope terms. Similarly to the analysis of the transformed data of fixations on the goal in Experiment 4, no convergence failures were reported; as such the correlation between random effects was included. For full model examples, see Appendix D.3. Plots of the transformed data and model fits are included in Figure 4.11.

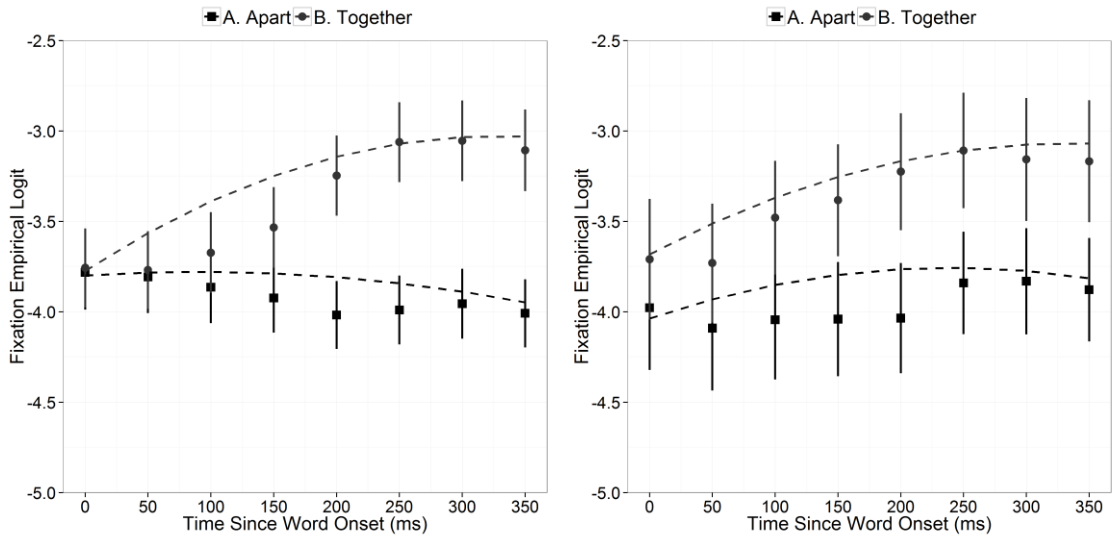


Figure 4.11. Model fits and fixations (transformed data) by participants (Left; N=40) and items (Right; N=20) on the goal (table) during the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 5; point-ranges represent the empirical logit and their standard errors

Statistical significance was calculated using the normal approximation. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 4.7. The Apart condition was the baseline for both analyses.

Table 4.7. By-participants [1] (N=40) and by-items [2] (N=20) parameter estimates for the transformed fixations on the goal (table) at the onset until the offset of the critical noun region ('book') in Experiment 5

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-3.829	0.120	-31.805	<.001***
Linear	-0.138	0.151	-0.912	.361
Quadratic	-0.082	0.065	-1.258	.208
Together	0.548	0.155	3.550	<.001***
Linear: Together	0.825	0.183	4.501	<.001***
Quadratic: Together	-0.142	0.088	-1.605	.109
By-items [2]				
Intercept	-3.840	0.126	-30.496	<.001***
Linear	0.204	0.152	1.343	.179
Quadratic	-0.158	0.058	-2.708	.007**
Together	0.561	0.160	3.503	.001**
Linear: Together	0.362	0.182	1.990	.047*
Quadratic: Together	-0.021	0.077	-0.277	.782

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 4.7 shows a significant difference on the intercept term for the Apart vs. Together comparison (p_1<.001; p_2<.001), with a larger proportion of (transformed) fixations on the goal object in the Together condition when compared to the Apart condition. There is also a significant difference on the linear term for the Apart vs. Together comparison, with the proportion of fixations on the goal increasing more rapidly over time in the Together condition when compared to the Apart condition (p_1<.001; p_2=.047). Taken together, this suggests that the goal object is fixated on more often, and thus generally more accessible throughout the entire time-window in the Together condition when compared to the Apart condition, but also that the rate of access for the goal object is faster in the Together condition when compared to the Apart condition as time goes on.

4.3.3.3. Looks on the boundary during the critical noun ('book')

In order to explore whether the lower proportion of transformed fixations on the source and goal locations could be explained by fixations on the previous location of the boundary, analyses of the transformed proportion of fixations on the boundary were carried out during the critical noun region ('book'). The average proportion of fixations on the boundary across conditions is displayed in Figure 4.12.

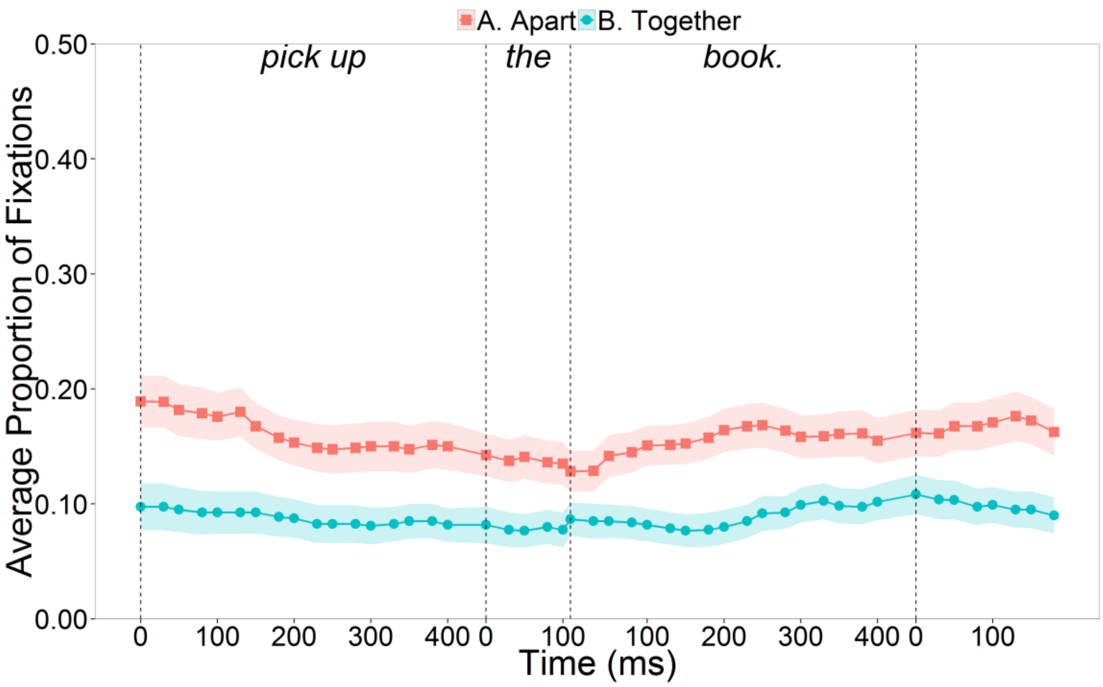


Figure 4.12. Average proportion of fixations on the boundary by participants (N=40) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 5; shaded bands show standard error

Figure 4.12 shows the average proportion of fixations on the boundary by participants across conditions. At the onset until the offset of the critical noun region ('book') the boundary receives a numerically larger proportion of fixations in the Apart condition (*M*=0.155, *SD*=0.116) than in the Together condition (*M*=0.088, *SD*=0.091). The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below. When observing the transformed data for fixations on the boundary during the critical region of analysis, one point of inflection was identified (see Figure 4.13). As such, the main effect of condition (Together vs. Apart) was modelled as a fixed factor using orthogonal linear and quadratic polynomials (Mirman et al., 2008).

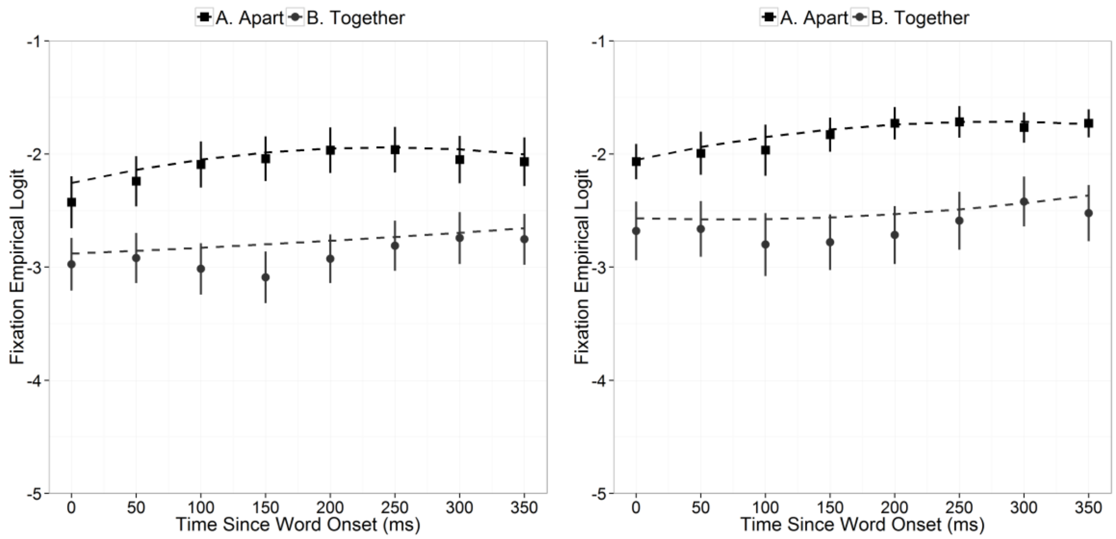


Figure 4.13. Model fits and fixations (transformed data) by participants (Left; N=40) and items (Right; N=20) on the boundary during the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 5; point-ranges represent the empirical logit and their standard errors

The same models used in the analysis of the transformed data for fixations on the boundary in Experiment 4 were used here. Time was modelled on the orthogonal linear and quadratic terms with fixed effects of condition (Apart vs. Together), and with random effects of participants/items and participants/items nested within condition on the intercept and slope terms. However, no convergence failures were reported when using the maximal converging random effects structure (Barr et al., 2013), as such the correlation between random effects was included. For full model examples, see Appendix D.3. Plots of the transformed data and model fits are included in Table 4.8.

Table 4.8. By-participants [1] (N=40) and by-items [2] (N=20) parameter estimates for the transformed fixations on the boundary at the onset until the offset of the critical noun region (‘book’) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models in Experiment 5

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-2.035	0.086	-23.725	<.001***
Linear	0.234	0.071	3.316	.001**
Quadratic	-0.172	0.034	-5.086	<.001***
Together	-0.741	0.096	-7.725	<.001***
Linear: Together	-0.028	0.097	-0.294	.769
Quadratic: Together	0.189	0.047	3.987	<.001***
By-items [2]				
Intercept	-1.816	0.067	-27.196	<.001***
Linear	0.290	0.056	5.213	<.001***
Quadratic	-0.143	0.024	-5.859	<.001***
Together	-0.697	0.064	-10.859	<.001***
Linear: Together	-0.102	0.060	-1.712	$.087^{+}$
Quadratic: Together	0.228	0.030	7.514	<.001***

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 4.8 shows a significant difference on the intercept term for the Apart vs. Together comparison, with a larger proportion of (transformed) fixations on the boundary in the Apart condition when compared to the Together condition (p_1<.001; p_2<.001). However, there is no significant difference between the Apart and Together conditions on the linear term for both analyses (p_1=.769; p_2=.087). Taken together, this suggests that the boundary is more accessible throughout the entire time-window in the Apart condition when compared to the Together condition, but that the rate of access for the boundary does not differ across conditions.

4.3.4. Discussion

Experiment 5 used the same materials as Experiment 4, but instead used the blank-screen paradigm to explore whether the co-presence of the visual scene might have influenced any of the results in Experiment 4 (i.e. in regards to fixations on the source, goal, and boundary locations). In using the blank-screen paradigm, the present experiment found a larger proportion of fixations on the source (book) in the Together condition when compared to the Apart condition throughout the entire time-window. Yet, fixations on the source location increased more rapidly in the Apart condition when compared to the Together condition (on the linear term). A larger proportion of fixations were found on the goal (table) in the Together condition (vs. the Apart condition) throughout the entire time-window, with fixations here increasing more rapidly (on the linear term) in the Together condition (vs. the Apart condition). Finally, the boundary received a larger proportion of fixations in the Apart condition (vs. the Together condition) throughout the entire time-window. Thus, while there is a potential trade-off in the rate of access for the source and goal locations – with the source location being accessed more rapidly in the Apart condition (vs. the Together condition) at a cost to the rate of access for the goal – both the source and goal locations are less accessible throughout the entire time-window in the Apart condition (vs. the Together condition), with the boundary between the two locations receiving a larger proportion of fixations in the Apart condition when compared to the Together condition.

Why, then, is the previous location of the boundary fixated on more so in the Apart condition than the Together condition? By using the blank-screen paradigm (e.g. Altmann, 2004), it is unlikely that any differences in visual attention are driven by differences in the visual saliency of the boundary when it is no longer present. Instead, it is likely that the larger proportion of fixations on the boundary in the Apart condition (vs. Together condition) could reflect a central gaze bias (Tatler, 2007), or a viewing strategy in which gaze is maintained between the source and goal locations prior to mention for the target object, which is picked up more often in the Apart condition than the Together condition due to the boundaries being located more centrally within the visual scene (and between the source and goal locations) in this case. If such behaviour were at play, this does not account for the differences across conditions in the proportion of fixations on the source and goal locations, suggesting that the lower proportion of fixations on the source and goal locations in the Apart condition (when compared to the Together condition) reflects event competition.

Alternatively, the larger proportion of fixations on the boundary in the Apart condition (vs. the Together condition) could come at a cost to fixations on the source and goal location. This could be the case either due to differences in the visual saliency of the boundary between the two conditions (i.e. between the source and goal in the Apart condition, but not in the Together condition), or differences in the simulated events across the two conditions (i.e. needing to open up and cross a doorway in the Apart condition, but not in the Together condition). For example, taking the perspective of a saliency-based account (e.g. Parkhurst et al., 2002), it is possible that the boundary detracted from fixations on both the source and goal locations more so in the Apart condition (vs. the Together condition) as the eyes must pass over and fixate on a third location in the Apart condition (but needn't do so in the Together condition) (Kamide, Lindsay, Scheepers, & Kukona, 2015). If so, then the present findings may simply reflect a difference in visual saliency across the two conditions.

Furthermore, it is possible that the larger proportion of fixations on the boundary in the Apart condition (vs. the Together condition) could reflect misallocation of fixations intended for the source location (but landing on an object close-by to the source location). If the current pattern of results reflects the latter case, this might suggest that event interference is at play in the Apart condition; the final instantiation of the object is less accessible because the initial instantiation of the object is more highly accessible. Indeed, the (linear) time-course for the proportion of fixations on the source and goal locations reflects this assumption; the rate of access for the source location is faster in the Apart condition, whereas the inverse is true for the goal location.

Finally, the present paradigm does not rule out the possibility that participants simulate a more complex sequence of events in the Apart condition when compared to the Together condition (Coll-Florit & Gennari, 2011); simulating opening the door to place the object on the table, or simulating the movement of the protagonist from the initial location to the final location, which is often associated with an increase in the looks on any boundary between the path of movement (Kamide et al., 2015). Yet, such an explanation is unsatisfactory as the movement event occurred earlier in the narrative, and as such comprehenders have no need to re-simulate the movement of the object from the source to the goal on re-mention for the target. Moreover, given the noticeable anticipatory effects in regards to the proportion of fixations on the boundary prior to mention for the target, it is unlikely that fixations on the boundary are prompted by access for the target object, but are driven instead by some difference in the visual saliency of the boundary, or by a difference in the probability to fixate on the location associated with the boundary across conditions (i.e. through the interest area being more centrally located in the Apart condition when compared to the Together condition).

Indeed, despite the explanations of the current findings based on a difference in visual saliency, by using the blank-screen paradigm (e.g. Altmann, 2004; Spivey & Geng, 2001) it is unlikely that the boundary was more highly salient in the Apart condition when compared to the Together condition as it was no longer present in the visual scene. As such, interpreting the present results in light of event competition, it is likely that the current experiment has shown that not only is the updated instantiation of the object less accessible upon hearing the critical noun in the Apart condition (i.e. Experiment 4), but so is the previous instantiation. In using this approach, the lower proportion of fixations on the source and goal locations – and larger proportion of fixations on the boundary location – in the Apart condition (when compared to the Together condition) is likely driven by factors aside from low-level attentional biases due to visual differences between the two conditions. Indeed, it is most likely that the source and goal are less accessible in the Apart condition when compared to the Together condition, and that any difference in the proportion of fixations on the boundary reflects a central gaze bias (Tatler, 2007) that is more likely to be detected in the Apart condition (vs. the Together condition). Such an argument is afforded further support given that the effects shown in the present experiment are largely similar to those reported in Experiment 4, but stronger. This suggests that, similarly to Experiment 2 of the present thesis, when a visual scene is not present during comprehension then comprehenders are more likely to use an event model to understand the unfolding discourse, with the relevant effects associated with this use more likely to be detected under these conditions.

Under the assumption that the present findings reflect a difference in accessibility for the source and goal locations due to a difference in event structure, then why might this be the case? The Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) proposes that when retrieving a piece of information (e.g. target object) associated with multiple event models (i.e. the Apart condition in the present experiment) then conflict occurs. This conflict is associated with a decrease in accessibility for probed-for information, likely due to an increase in processing costs and working memory demands. If the Apart condition ensures that both instantiations of the moved object are associated with separate event models, upon hearing the critical noun and attempting to resolve its referent then processing costs and working memory demands should be higher in this condition than the Together condition. Given that an increase in working memory load is associated with slower target detection while in the presence of a distractor (Lavie & De Fockert, 2005), and that participants with a low working memory span are slower and less accurate than high-span participants in anti-saccade tasks (Kane, Bleckley, Conway, & Engle, 2001), it is likely that working memory plays a role in the control of visual attention here. Furthermore, because word identification is typically slower when under high working memory load (see Experiment 6 in Baddeley, Lewis, Eldridge, & Thomson, 1984), it is likely that identification and resolution for the correct referent related to the critical noun takes longer in the Apart condition, causing a lower proportion of fixations to be allocated to either the source or goal location in the Apart condition (vs. the Together condition). This would suggest that event competition could be the mechanism at play when attempting to access information associated with two distinct event models; both the initial and final instantiation of the object are less accessible in the Apart condition when compared to the Together condition due to higher working memory demands associated with the need to maintain and select between two relevant event models associated with the target object; i.e. due to event competition. However, as noted above, such an account is present impossible to divorce from that of a saliency-based account (e.g. Parkhurst et al., 2002), or an account based around simulating a more complex sequence of events (Coll-Florit & Gennari, 2011).

Given the interpretations described above, the current results suggest that the lower proportion of fixations on the source and goal locations in the Apart condition when compared to the Together condition is driven either by (a) visual biases associated with the initial presentation of the visual scene prior to the onset of the blank-screen resulting in a larger proportion of fixations on the boundary location at a cost to fixations on the source and goal locations in the Apart condition (vs. the Together condition); (b) differences in the simulated sequence of events on mention for the object, in which comprehenders simulate movement across the boundary in the Apart condition (but not in the Together condition), causing a larger proportion of fixations on the boundary at a cost to fixations on the source and goal locations in the Apart condition (vs. the Together condition); or (c) higher working memory costs associated with maintaining and selecting between two relevant event models in the Apart condition, resulting in (i) lower accessibility for both the source and goal locations or (ii) lower accessibility for the goal location due to increased accessibility for the source location. Yet, both of the outcomes associated with higher working memory load cannot sufficiently explain why there are a larger proportion of fixations on the boundary in the Apart condition when compared to the Together condition without making assumptions about visual processing strategies in the blank-screen paradigm.

In order to differentiate between the explanations laid out above, Experiment 6 aims to make a number of changes to the experimental paradigm. Most importantly, the type of boundary included within items will be manipulated, with half of the items using the typical doorway-type boundaries, and half of the items using line-type boundaries. This will allow for an exploration into whether any differences in the proportion of fixations on the source and goal locations are driven by simulating more complex events in the Apart condition (i.e. opening the door), or due to categorisation of the two instantiations of the object into separate or the same rooms/event models. In order to ensure that participants are aware of the differences in boundary-type, visual scenes will remain on-screen during the presentation of the auditory stimuli. In order to establish whether any fixations on the source and goal locations are driven by mental representations of where the object was/is, these two locations (previously the book and table) will be replaced with containers; as such, the narrative will describe the movement of an object from one container to another, before making reference back to this (unseen) object. By making these changes, Experiment 6 aims to explore primarily whether any difference in accessibility for the initial and final instantiation of the object is driven by differences in event structure or by the saliency of the boundary across conditions.

4.4. Experiment 6

4.4.1. Introduction

The current experiment has been designed in order to address a number of issues with the previous paradigm outlined in sections 4.2.3 and 4.3.4. Primarily, the current experiment will address the influence of the boundary on guiding visual attention differentially across conditions. In Experiments 4 and 5, it was not clear what drives visual attention towards either of the locations associated with the moved object, and whether any differences in conditions on the proportion of fixations on these locations was driven by low-level visual differences across conditions. While Experiment 5 aimed to address this issue by removing the visual scene prior to the onset of the auditory discourse, it is possible that the same issues may have persisted there; participants might fixate regions that were previously associated with features that differ in saliency across conditions (Parkhurst et al., 2002), or they could differentially fixate on regions within the visual scene due to differences in interpretations of the events described by the discourse (e.g. in time taken, see Coll-Florit & Gennari, 2011). Addressing the first point, while the visual saliency across conditions cannot be equivalent if the experiment aims to introduce different visual scenes (i.e. in the location of the boundary) such that participants segment information into different locations, the amount of attention directed towards the features that differ might be reduced by reducing their size. In doing so, this opens up an avenue to also address the second point; if any differences across conditions are driven by differences in the representations of actions carried out by the protagonist, i.e. walking to the table/book vs. opening a door before walking to the table/book, then removing large doorway-type boundaries should surely remove any effect. By replacing the doorway-type boundaries with simple line-type boundary divisions between the two rooms, this should help to establish whether any reported effects are driven by highly-salient visual differences between conditions, differences in the interpreted actions carried out by the protagonist, or differences in the association of the two instantiations of the object with one event model or two separate event models.

In order to increase the power in the current experiment, instead of rotating orthogonally across these two factors with four conditions, the filler items used in Experiments 4 and 5 have been replaced with the new line-type boundary items. This decision was also made to reduce the time taken to run the experiment with fillers such that participants stayed engaged with the task throughout. Given that the current experiment requires for participants to focus upon and form a situation model of the discourse, engagement with the task was deemed to be critical here. Moreover, it was expected that this change should increase the predictability of the task, potentially allowing for participants to focus on accessing the target object when mentioned, and not on other features not directly associated with the aim of the present chapter (e.g. the boundary). In a similar vein, the final sentence of the discourse was elongated prior to the critical noun (and the critical region for analysis). This was done for two reasons: (1) to ensure that eye-movements during the critical noun were more reflective of access for the target object, with less interference associated with the recent mention of other objects in the visual scene (e.g. the distractor), and (2) to reduce any effect of an increase in processing load in the Apart condition associated with a recent shift across an event boundary (Reynolds, Zacks, & Braver, 2007).

Finally, as mentioned in section 4.3.4, in order to also increase the proportion of fixations on the source and goal locations on mention, and to provide participants with clear indications of where the boundaries between locations lie, the current experiment employed a concurrent visual-world paradigm. In doing so, it was necessary to replace the initial and final locations of the moved object with containers such that fixations on either region were guided primarily by the mental representation of where the object was, and not by any conflicting visual sources of information. It was hypothesised that together, these changes should help to increase the proportion of fixations on the source and goal locations on mention of the critical noun, and thus help to improve any chance of finding an effect driven by event structure, and not any other possible confounds associated with the design in Experiments 4 and 5. It is predicted that if accessibility for the final instantiation of the object is indeed driven by some sort of event competition mechanism, then the proportion of fixations on the source and goal locations should be lower in the Apart condition than the Together condition regardless of the type of boundary placed between these locations in the visual scene.

4.4.2. Method

4.4.2.1. Participants

Sixty (12 male) native English speakers from the University of Dundee (aged 16-56, *M* =23.88, *SD*= 8.46) took part in this study for partial course credit or for £3. All participants had normal or corrected to normal vision, and had no known auditory, visual, or language disorders. No participants in this study had previously taken part in Experiment 4 or 5 of the present thesis.

4.4.2.2. Apparatus

The same apparatus used in Experiments 1, 2, 4, and 5 were used here, using a 9-point calibration every 8^{th} trial.

4.4.2.3. Materials

Similar materials to those used in Experiments 4 and 5 were used here; however several changes were made to the stimuli. Similarly to Experiments 4 and 5, visual scenes depicted two rooms containing several objects. However, in half of the items, the boundary separating the two rooms was a Doorway-type boundary (Figure 4.14), and in the other half a Line-type boundary (Figure 4.15). In all items, the source (book) and two potential goals (chair, table) were changed to containers (i.e. handbag, folder, and box, respectively). Because of this change, the discourse described movement of an object (e.g. book) from one container (e.g. handbag) to another (e.g. folder). This change was made to ensure that accessibility for the representation of the moved object in the initial location was not driven by any sort of low-level referential processing, i.e. looking at the book upon hearing ‘book’. Furthermore, the discourse in the second sentence was lengthened to include an adverbial phrase (i.e. ‘and <u>then very slowly</u> pick up the book’). This change was made to reduce the likelihood that participants dwelled on locations other than the target object while processing the upcoming discourse associated with the target in order to obtain a larger effect (if present). Example visual scenes and paired sentential stimuli are provided in Example 4.2 for Doorway-type boundary items and in Example 4.3 for Line-type boundary items.

Example 4.2. An example of the linguistic stimuli accompanying visual scenes depicting the Doorway-type boundary items (e.g. Figure 4.14) in Experiment 6

(1) The woman will move the book from the handbag into the folder.
(2) Then she will study the painting and then very slowly pick up the book.

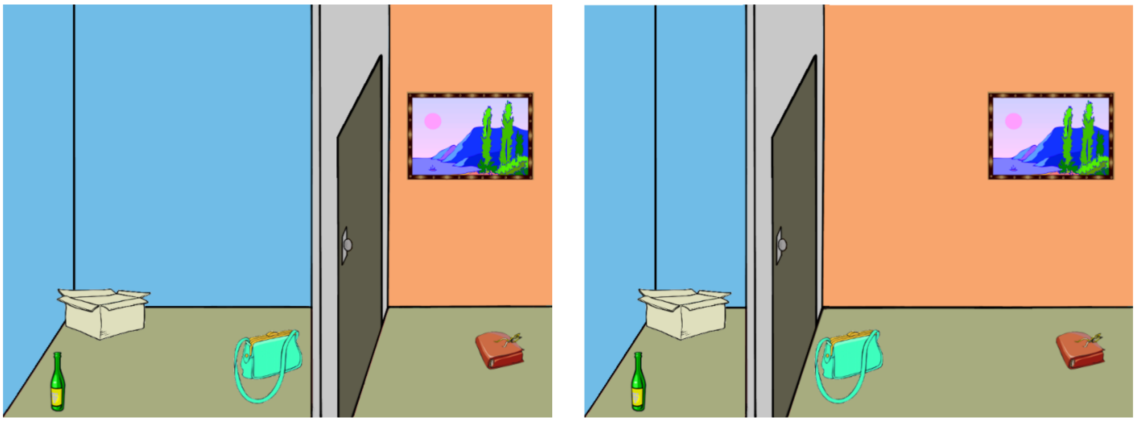


Figure 4.14. Example visual scenes accompanying spoken sentences (e.g. Example 4.2) for the Doorway-type boundary items in Experiment 6: (a) Apart condition (left) and (b) Together condition (right)

Example 4.3. An example of the linguistic stimuli accompanying visual scenes depicting the Line-type boundary items (e.g. Figure 4.15) in Experiment 6

(1) The banker will transfer the trainers from the gift box into the laundry basket.
(2) Then he will look at the plant and then very quickly grab the trainers.

Figure 4.15. Example visual scenes accompanying spoken sentences (e.g. Example 4.3) for the Line-type boundary items in Experiment 6: (a) Apart condition (left) and (b) Together condition (right)

The experimental conditions pertained to whether the presented visual scene depicted the source container (handbag/gift box) and the goal (folder/laundry basket) together in one room or apart in two separate rooms, i.e. whether there was a doorway between the described path of movement of the object from the source to the goal (Apart condition) or not (Together condition). In half of the items a doorway separating the rooms was located between the source and the goal in the Apart condition (Figure 4.14a) or not in the Together condition (Figure 4.14b), whereas in the other half, a line-type boundary was located between the source and the goal in the Apart condition (Figure 4.15a) or not in the Together condition (Figure 4.15b). In the Together condition, both instantiations of the book were maintained within one event model, whereas in the Apart condition they were in separate event models.

The distance between the source and goal was identical across pairs. The source was always located in the centre of the visual scene, but varied in its vertical orientation. The direction of movement of the object from the source to the goal was counterbalanced across items so that goals were equally likely to appear in each of the four corners of either room. The orientation of boundaries was also counterbalanced equally across items, with specific regard to the direction of movement of the object from the source, such that the object moved across a left and right-facing boundary an equal number of times across items. No filler items were included in the testing session to increase the predictability of the discourse across the entire testing session. In the first sentence, each item used unique protagonist nouns; however verbs were rotated four times across ten possible verbs in all items, such that any verb was used twice for the doorway-type items and twice for the boundary-type items. In the second sentence, both types of verbs were rotated four times across ten possible verbs, such that any verb was used twice for the Doorway-type and Line-type boundary items. All objects and source and goal locations were only named once across all items; all depicted objects in the visual scenes were unique across items. The combination of nouns and verbs was randomised.

Two fully randomised lists were created for the items. Both lists were randomised per participant and had a run length of 2 for item-type and condition, so that only two items from the same condition and from the same item-type would be presented sequentially. Four practice trials were included; two items used Doorway-type boundaries, and two used Line-type boundaries, with one of each condition included in both types of item. Each list contained one version of the two sentential conditions corresponding to each of the 40 experimental items. For a full list of the sentential stimuli used for recorded sentences, see Appendix E.1. For examples of all visual scenes, see Appendix E.2.

4.4.2.4. Procedure

A similar procedure to that used in Experiment 4 was used here. Participants were presented with one of two visual scenes depicting two rooms separated by a boundary or not, with the boundary type varying across items (Doorway: Figure 4.14a/Figure

4.14b; Line-type boundary: Figure 4.15a/Figure 4.15b). Visual scenes and auditory stimuli were presented concurrently in order to ensure that participants had visual information about the spatial relations among objects (e.g., source, boundary, goal) when they were processing the linguistic discourse.

Participants completed four practice trials at the beginning of the experiment. The practice trials consisted of two Doorway-type boundary items and two Line-type boundary items, with one of each condition displayed for each item-type. Following the practice section, participants were given the opportunity to ask the experimenter any questions before starting the experiment. The experimental session consisted of 40 experimental items as outlined in Section 4.4.2.3. For all trials, each scene was programed to be displayed for a preview of 1000ms, although due to experiment error the average preview was 1050ms. From preview, the visual scene remained onscreen for the duration of the trial (average of 17, 220ms). After the preview of the visual scene, the first sentence played. The second (critical) sentence was programed to be played 1000ms after the offset of the first sentence, but played 20ms after this. Each individual trial was automatically terminated 4000ms after the offset of the final sentence. The average durations, onsets, and offsets for each region are presented in Table 4.9. The full testing session lasted approximately 35 minutes.

4.4.3. Results

Data were prepared and analysed using R version 2.15.0 (R Development Core Team, 2008), using the `lme4` package (version 1.0-5). A similar method of analysis used in Experiments 4 and 5 were used here. Looks on the source, goal and boundary were analysed separately, comparing differences between conditions. The time-course of this region was determined on a trial-by-trial basis (see Table 4.9 for mean durations). The transformed proportion of fixations on the source, goal, and boundary were calculated starting from the onset of the first saccade towards the target, until the offset of the critical region within each (hand drawn) region of interest. Following Barr (2008), the region of analysis was determined at the earliest point at which eye movements to the source, goal, or boundary were driven by the linguistic stimuli. However, because no point of inflection seemed to be driven by the linguistic stimuli, this point was determined as the onset of the critical noun (‘book’). The mean duration of fixations was calculated for each time window. Table 4.9 shows the average onset, offset, and duration for each region, taking into account variability with onsets as a result of the experimental program.

Table 4.9. Mean durations of temporal regions in the experimental sentences (ms) in Experiment 6

Label	Region	Onset	Offset	Duration
Sentence 1				
Start	‘The woman will move the book from the’	1050	4360	3310
Source	‘handbag’	4360	5010	650
Preposition & determiner	‘into the’	5010	5840	830
Goal	‘folder’	5840	6490	650
Sentence 2				
Start	‘Then she will’	5840	6490	650
Verb	‘study’	7510	8480	970
Determiner	‘the’	8480	9140	660
Distractor	‘painting’	9140	9310	170
Adverbial phrase	‘and then very slowly’	9310	10,060	750
Verb phrase	‘pick up’	10,060	11,990	1930
Determiner	‘the’	11,990	12,550	560
Target	‘book’	12,550	12,700	150

Empirical logit analyses (Barr, 2008) were conducted to analyse the average fixations (log odds scale) to the source (handbag) , goal (folder), and boundary at the onset until the offset of the critical noun (‘book’). Separate analyses were run for the transformed data on each interest area. For each analysis, two models were created and run separately for by-participants and by-items analyses respectively, exploring whether association of the two locations of the book (in the handbag or in the folder) with the same or separate locations, and hence association of the two instantiations of the book with the same or separate event models, influenced fixations on the each interest area. Furthermore, the type of boundary for each item (Doorway/Line-type boundary) was also included in the same analysis in order to explore any differences across conditions as a result of the type of boundary used in each item. Given that boundary type was not rotated across each item, but instead constituted a sub-set of the items, any interpretation from the main effects of boundary type must be interpreted in light of any differences across the item sub-sets. However, given that the same criteria for developing items were applied to both Doorway-type and Line-type boundary items, any differences across the item types were minimised.

4.4.3.1. Looks on the source (handbag) during the critical noun (‘book’)

Analyses of the transformed proportion of fixations on the source (handbag) were carried out during the critical noun region (‘book’). The average proportion of fixations on the source (handbag) across conditions is displayed in Figure 4.16.

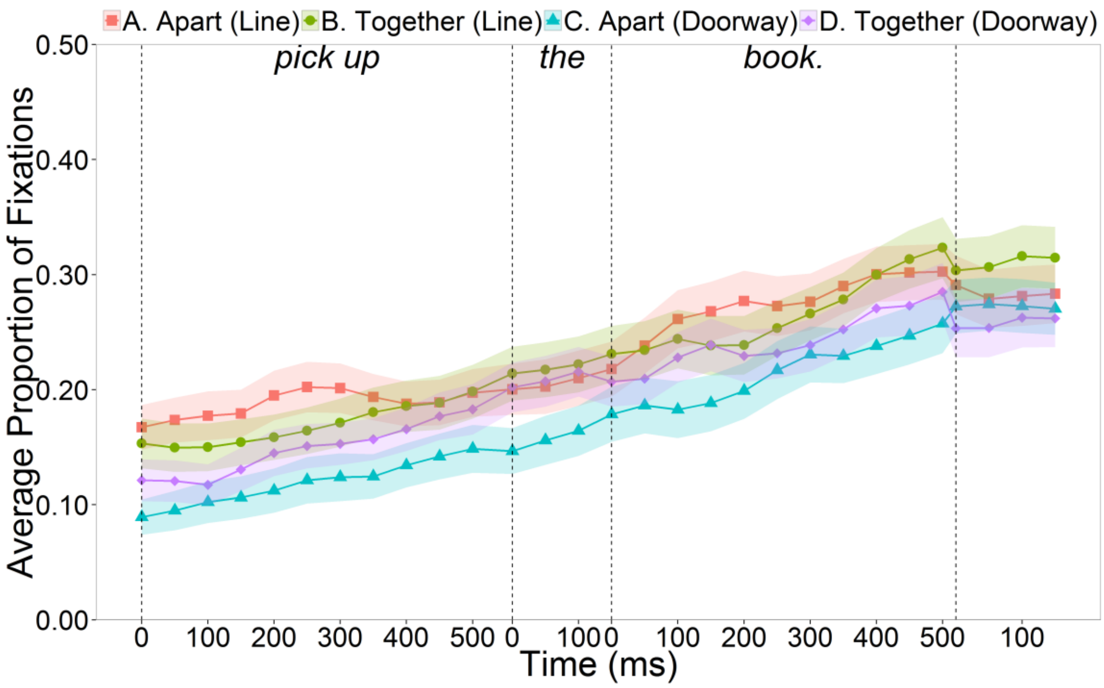


Figure 4.16. Average proportion of fixations on the source (handbag) by participants (N=60) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models for Doorway-type and Line-type boundary items in Experiment 6; shaded bands show standard error

Figure 4.16 shows the average proportion of fixations on the source (handbag) by participants across conditions, the values of which are reported during the critical noun region (‘book’) in Table 4.10. The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

Table 4.10. Means (*SD*) for the proportion of fixations on the source (handbag) during the critical noun (‘book’) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models for Doorway-type and Line-type boundary items in Experiment 6

	Apart	Together	Total
Doorway-type boundary	0.210 (0.188)	0.238 (0.177)	0.224 (0.183)
Line-type boundary	0.270 (0.190)	0.260 (0.190)	0.265 (0.190)
Total	0.240 (0.191)	0.249 (0.183)	–

Empirical logit analyses were conducted to analyse the average fixations (log odds scale) to the source (handbag) at the onset until the offset of the critical noun (‘book’). Two models were created and run separately for by-participants and by-items analyses respectively, exploring the main effect of Togetherness (Together vs. Apart) and Boundary-type (Doorway vs. Line) modelled as fixed factors. Because Boundary-type only differed between items and not within, each model only contained 20 items per Boundary-type, which varied according to Togetherness (Together vs. Apart). Inspection of the observed transformed data in Figure 4.17 revealed one point of inflection in fixations throughout the critical noun time-window; as such second-order (quadratic) orthogonal polynomials were preferred over lower-order orthogonal polynomials in this analysis (Mirman et al., 2008).

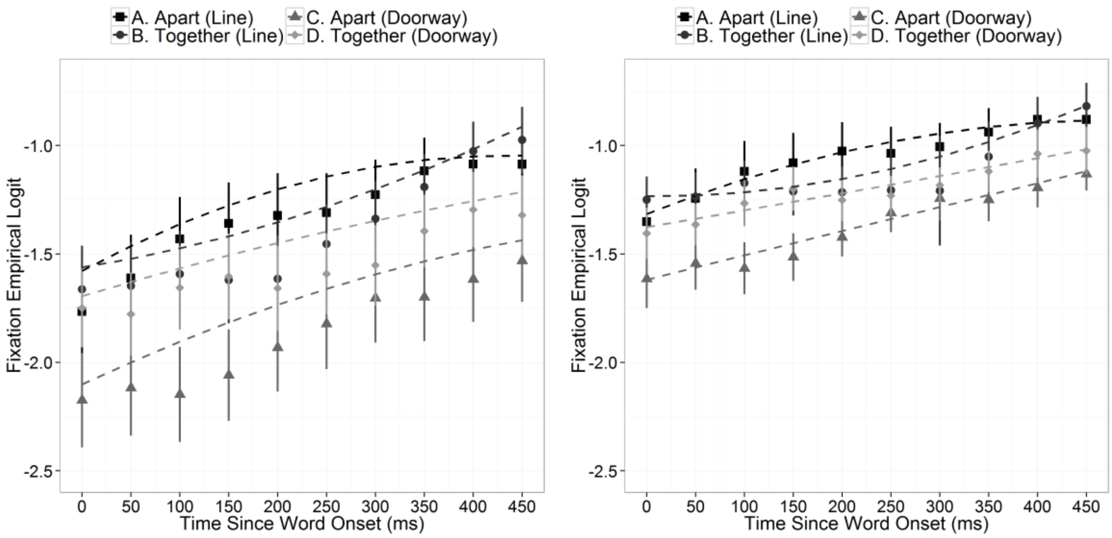


Figure 4.17. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=40) on the source (handbag) during the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models for Doorway-type and Line-type boundary items in Experiment 6; point-ranges represent the empirical logit and their standard errors

Similarly to Experiment 3, in the by-participants and by-items models, deviation coding was used such that the baseline for each model was the difference between the levels of a given factor. In the current experiment, the two levels for Togetherness – Apart and Together, were coded as -.5 and .5 respectively. The two types of Boundary used in each item was also coded as a fixed factor using deviation coding such that the Line-type and Doorway-type items were coded as -.5 and .5 respectively (see 6.2.Appendix E.3 for an example). In doing so, and with using orthogonal polynomials for the time term, the intercept parameter represents the grand mean of all four conditions throughout the entire time window. For the Togetherness and Boundary terms, the baseline for these factors is centred at the mean of both levels, such that the value (positive or negative) in parameter estimates shows the direction of effect for each factor. A similar interpretation can be made for the interaction terms, with only the final factor in the interaction terms being allowed to vary across levels.

Due to a failure to converge using a maximal random effects structure, the correlations between random effects were removed (see Barr et al., 2013 for a discussion). For the by-participants analysis, random effects of participants and participants nested within Togetherness and Boundary type were included on the intercept and slope terms. For the by-items analysis, random effects of item and item nested within Togetherness was included on the intercept and slope terms, however random effects of item nested within

Boundary-type were only included on the intercept term, with random effects of Boundary-type included on the slope term (i.e. dropping by-item random slopes for boundary-type). For full model examples, see Appendix E.4.

For both models, statistical significance for individual parameter estimates was calculated using the normal approximation. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 4.11.

Table 4.11. By-participants [1] (N=60) and by-items [2] (N=40) parameter estimates for the transformed fixations on the source (handbag) at the onset until the offset of the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models for Doorway-type and Line-type boundary items in Experiment 6

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-1.419	0.047	-30.293	<.001***
Linear	0.587	0.035	16.719	<.001***
Quadratic	-0.046	0.016	-2.851	.004**
Togetherness	0.116	0.031	3.718	<.001***
Linear: Togetherness	-0.034	0.057	-0.601	.548
Quadratic: Togetherness	0.150	0.029	5.142	<.001***
Boundary-type	-0.324	0.031	-10.337	<.001***
Linear: Boundary-type	-0.017	0.057	-0.298	.765
Quadratic: Boundary-type	-0.025	0.029	-0.847	.397
Togetherness: Boundary-type	0.347	0.063	5.545	<.001***
Linear: Togetherness: Boundary-type	-0.307	0.113	-2.711	.007**
Quadratic: Togetherness: Boundary-type	-0.208	0.058	-3.566	<.001***
By-items [2]				
Intercept	-1.175	0.011	-111.782	<.001***
Linear	0.431	0.163	2.653	<.008**
Quadratic	0.004	0.007	0.525	.599
Togetherness	0.062	0.016	3.966	<.001***
Linear: Togetherness	-0.078	0.026	-3.071	.002**
Quadratic: Togetherness	0.119	0.014	8.341	<001***
Boundary-type	-0.217	0.021	-10.304	<.001***
Linear: Boundary-type	0.005	0.325	0.017	0.987
Quadratic: Boundary-type	-0.008	0.015	-0.558	.577
Togetherness: Boundary-type	0.214	0.031	6.859	<.001***
Linear: Togetherness: Boundary-type	-0.129	0.051	-2.55	0.012*
Quadratic: Togetherness: Boundary-type	-0.224	0.028	-7.888	<.001***

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 4.11 shows a significant difference between the Apart and Together conditions on the intercept term (p_1< .001; p_2< .001) for the (transformed) fixations on the source (handbag) during the critical noun ('book'), with a larger proportion of transformed fixations on the source in the Together condition when compared to the Apart condition.

However, there was a no reliable difference between the Apart and Together conditions on the linear time term (p_1= .548; p_2= .002).

There is also a significant difference between the Line-type and Doorway-type boundary items for the transformed fixations on the source on the intercept term (p_1< .001; p_2< .001), with a larger proportion of transformed fixations on the source (book) in the Line-type items (vs. Doorway-type items). However, there is no difference between the Line-type and Doorway-type boundary items on the linear term (p_1= .765; p_2= .987). This is not altogether unexpected, as if there is a general visual bias to fixate on the source more often when using Line-type boundaries, this effect should persist throughout the entire time window, and not increase as time goes on. Interestingly, there is a 2-way interaction between the Togetherness conditions (Apart vs. Together) and Boundary-type (Line vs. Doorway) (p_1< .001; p_2< .001); with a larger difference between the two conditions when using Doorway-type items. Here, there are a larger proportion of fixations on the source in the Together condition when compared to the Apart condition throughout the entire time-window. However, for the Line-type boundary items, there are a larger proportion of fixations on the source in the Apart condition when compared to the Together condition.

Finally, there is a significant 3-way interaction between Togetherness and Boundary-type on the linear term (p_1= .007; p_2= .012). By observing Figure 4.17 it is clear that within the Line-type boundary items, the source object is fixated on more rapidly in the Together condition (vs. the Apart condition), whereas in the Doorway-type items the source is fixated on more rapidly in the Apart condition (vs. the Together condition).

Together, these results suggest that the source is more accessible in the Together condition when compared to the Apart condition throughout the entire time-window. However, observing the interaction between Boundary-type and Togetherness, this effect is only supported with Doorway-type boundaries (with the opposite effect found when using Line-type boundaries). Furthermore, the source is more accessible throughout the entire time-window when using Line-type rather than Doorway-type boundaries. Finally, there is an interaction between these two factors whereby the source is accessed more rapidly in the Together condition (vs. the Apart condition) when using Line-type boundary items, and the source is accessed more rapidly in the Apart condition (vs. the Together condition) when using Doorway-type boundary items.

4.4.3.2. Looks on the goal (folder) during the critical noun ('book')

Analyses of the transformed fixations on the goal (folder) were carried out during the critical noun region ('book'). The average proportion of fixations on the goal (folder) across conditions is displayed in Figure 4.18.

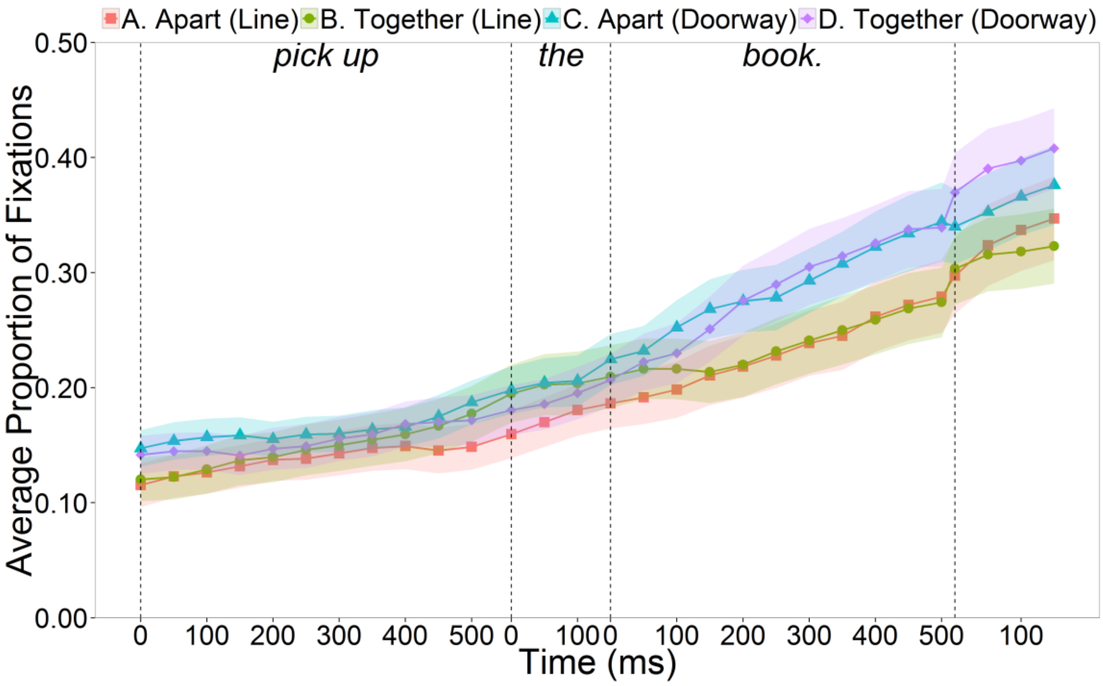


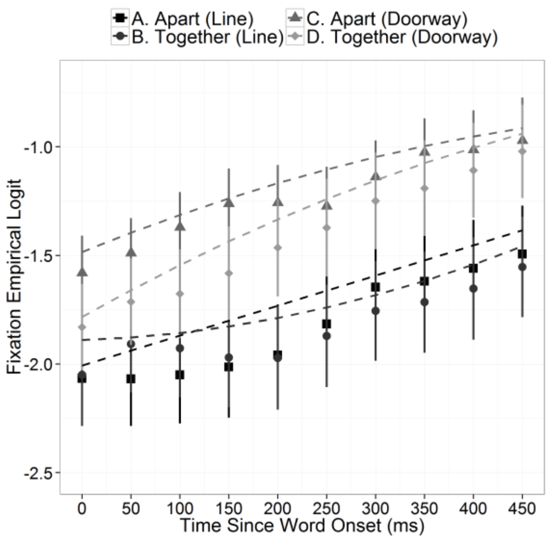
Figure 4.18. Average proportion of fixations on the goal (folder) by participants (N=60) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models for Doorway-type and Line-type boundary items in Experiment 6; shaded bands show standard error

Figure 4.18 shows the average proportion of fixations on the goal (folder) by participants across conditions, the values of which are reported during the critical noun region ('book') in Table 4.12. The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

Table 4.12. Means (*SD*) for the proportion of fixations on the goal (folder) during the critical noun ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models for Doorway-type and Line-type boundary items in Experiment 6

	Apart	Together	Total
Doorway-type boundary	0.279 (0.210)	0.276 (0.233)	0.277 (0.221)
Line-type boundary	0.225 (0.209)	0.233 (0.218)	0.229 (0.214)
Total	0.252 (0.211)	0.254 (0.226)	–

Similar models used in the analysis of the transformed data for fixations on the source (handbag) were used here. Specifically, time was modelled on the orthogonal linear and quadratic terms with fixed effects of Togetherness (Apart vs. Together) and Boundary-type (Doorway vs. Line). For the by-participants analysis, random effects of participants and participants nested within Togetherness and Boundary type were included on the intercept and slope terms. For the by-items analysis, random effects of item and item nested within Togetherness was included on the intercept and slope terms, however random effects of item nested within Boundary-type were only included on the intercept term, with random effects of Boundary-type included on the slope term (i.e. dropping by-item random slopes for boundary-type). Both of the fixed effects were again modelled using the same deviation-coding structure (Apart and Together were coded as -.5 and .5 respectively, Line-type and Doorway items were coded as -.5 and .5 respectively). Because no convergence failure was reported in the by-participants analysis, a maximal random effects structure was used here. However, for the by-items analysis, the model containing the maximal random effects structure failed to converge. As such, the correlations between random effects were removed (see Barr et al., 2013). For full model examples, see Appendix E.4. Plots of the transformed data and model fits are included in Figure 4.19.



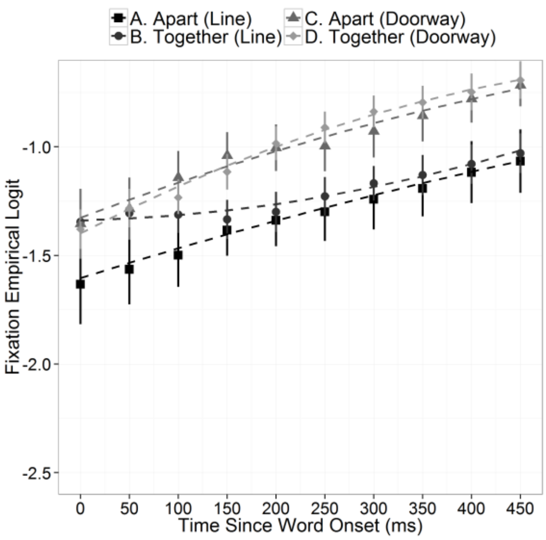


Figure 4.19. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=40) on the goal (folder) during the critical noun region (‘book’) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models for Doorway-type and Line-type boundary items in Experiment 6; point-ranges represent the empirical logit and their standard errors

Statistical significance was calculated using the normal approximation. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 4.13.

Table 4.13. By-participants [1] (N=60) and by-items [2] (N=40) parameter estimates for the transformed fixations on the goal (folder) at the onset until the offset of the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models for Doorway-type and Line-type boundary items in Experiment 6

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-1.475	0.055	-26.877	<.001***
Linear	0.623	0.053	11.705	<.001***
Quadratic	-0.013	0.014	-0.943	.346
Togetherness	-0.094	0.039	-2.419	.016*
Linear: Togetherness	0.042	0.059	0.713	.476
Quadratic: Togetherness	0.045	0.026	1.726	.084+
Boundary-type	0.473	0.039	12.196	<.001***
Linear: Boundary-type	0.180	0.059	3.065	.002**
Quadratic: Boundary-type	-0.132	0.026	-5.056	<.001***
Togetherness: Boundary-type	-0.124	0.077	-1.600	.110
Linear: Togetherness: Boundary-type	0.470	0.118	3.992	<.001***
Quadratic: Togetherness: Boundary-type	-0.115	0.052	-2.209	.027*
By-items [2]				
Intercept	-1.134	0.010	-100.772	<.001***
Linear	0.548	0.012	44.702	<.001***
Quadratic	-0.023	0.011	-2.130	.033*
Togetherness	0.055	0.016	3.513	<.001**
Linear: Togetherness	-0.055	0.022	-2.476	.014*
Quadratic: Togetherness	0.029	0.013	2.310	.021*
Boundary-type	0.270	0.020	13.194	<.001***
Linear: Boundary-type	0.220	0.025	8.988	<.001***
Quadratic: Boundary-type	-0.099	0.021	-4.633	<.001***
Togetherness: Boundary-type	-0.092	0.031	-2.932	.003**
Linear: Togetherness: Boundary-type	0.335	0.044	7.538	<.001***
Quadratic: Togetherness: Boundary-type	-0.153	0.025	-6.122	<.001***

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 4.13 shows a significant difference between the two Togetherness conditions (Apart vs. Together) on the intercept term (both p_1=.016; p_2<.001) for the (transformed) fixations on the goal (folder) during the critical noun ('book'). However, the direction of effect shows a larger proportion of fixations on the goal in the Apart condition (vs. Together condition) for the by-participants analysis, and a larger proportion of fixations on the goal in the Together condition (vs. the Apart condition) for the by-items analysis. Aside from the differences between conditions on the intercept term, there is a non-reliable difference between the two conditions on the linear term (p_1=.476, p_2=.014).

One reason for the discrepancy in the direction of effects for the Togetherness factor across the by-participants and by-items analyses could lie in the differences in what is interpreted in the model. In the by-participants analysis, items do not vary by Boundary-type, but this is not apparent to the model; whereas for the by-items analysis, Boundary-type is incorporated as a between-items factor. As such, interpreting the current results in light of an interaction between the Togetherness and Boundary-type factors is most appropriate.

For Boundary-type (Line vs. Doorway), there is a significant difference on the intercept and linear terms in the positive direction (all *ps*<.05), indicating that the goal receives a larger proportion of fixations throughout the entire time-window and as time goes on when using Doorway-type items. Similarly to the larger proportion of fixations on the source object (handbag) in the Line-type boundary items, this result is not altogether unexpected as we might predict that when the narrative dictates that the current sequence of events are isolated in one location, the proportion of fixations on the goal object should be higher when there is a clear boundary between the two locations (and lower on the source object when present).

While there is no reliable 2-way interaction between the Togetherness and Boundary type (p_1=.110; p_2=.003) factors, there is a significant 3-way interaction between Togetherness, Boundary-type and the linear time-term (p_1<.001; p_2<.001); observing Figure 4.19, while fixations on the goal generally increase across both Togetherness conditions, the rate of access for the goal is faster in the Together condition when compared to the Apart condition in Doorway-type boundary items only.

Together, these results suggest that the goal is more accessible throughout the entire time-window and as time goes on when using Doorway-type (vs. Line-type) items, and that the rate of access for the goal is faster in the Together condition when compared to the Apart condition when using Doorway-type items only.

4.4.3.3. Looks on the boundary during the critical noun (‘book’)

In order to explore whether the differences in the transformed fixations on the source and goal locations across conditions could be explained by differences in the transformed fixations on the boundary, analyses of the transformed fixations on the boundary were carried out during the critical noun region (‘book’). The average proportion of fixations on the boundary across conditions is displayed in Figure 4.20.

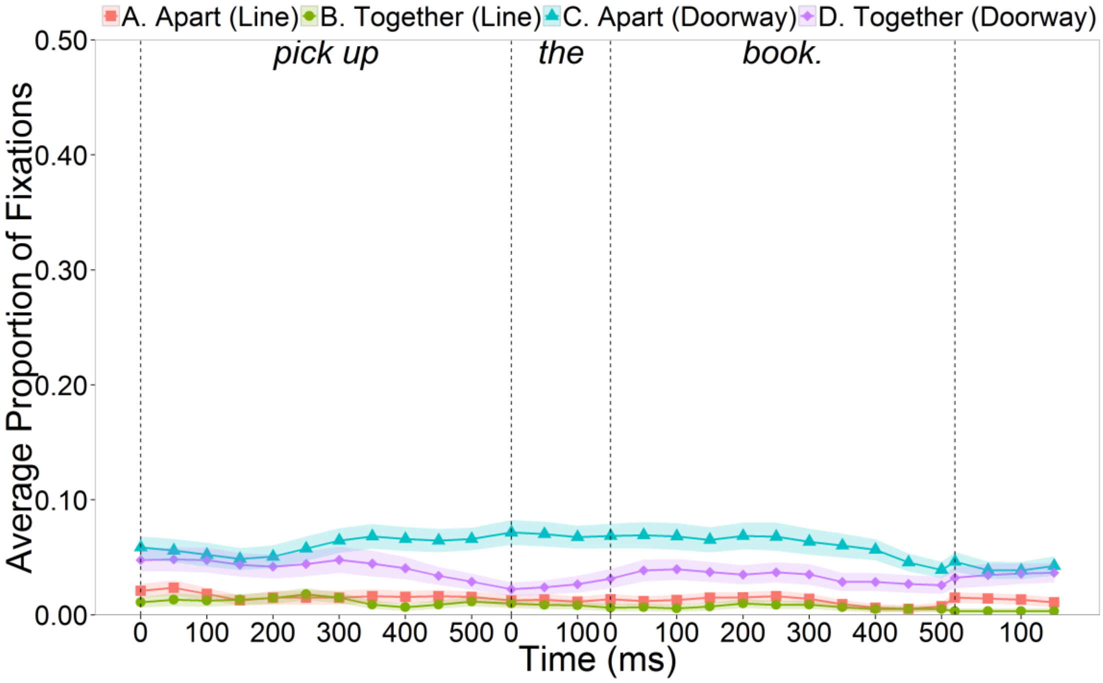


Figure 4.20. Average proportion of fixations on the boundary by participants (N=60) as a measure of whether the source and goal were Together in the same event model or Apart in separate event models for Doorway-type and Line-type boundary items in Experiment 6; shaded bands show standard error

Figure 4.20 shows the average proportion of fixations on the boundary by participants across conditions, the values of which are reported during the critical noun region ('book') in Table 4.14. The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

Table 4.14. Means (*SD*) for the proportion of fixations on the boundary during the critical noun ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models for Doorway-type and Line-type boundary items in Experiment 6

	Apart	Together	Total
Doorway-type boundary	0.064 (0.082)	0.034 (0.065)	0.049 (0.075)
Line-type boundary	0.012 (0.032)	0.007 (0.025)	0.010 (0.029)
Total	0.038 (0.067)	0.021 (0.051)	–

When observing the transformed data for fixations on the boundary during the critical region of analysis, one point of inflection was identified (see Figure 4.21). As such, the main effect of condition (Together vs. Apart) was modelled as a fixed factor using orthogonal linear and quadratic polynomials (Mirman et al., 2008).

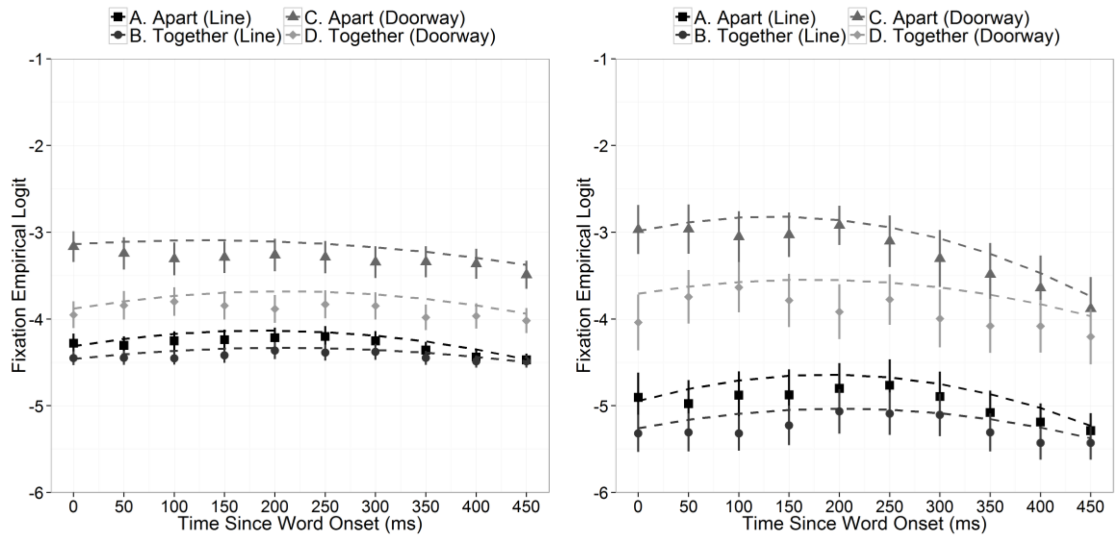


Figure 4.21. Model fits and fixations (transformed data) by participants (Left; N=40) and items (Right; N=20) on the boundary during the critical noun region ('book') as a measure of whether the source and goal were Together in the same event model or Apart in separate event models for Doorway-type and Line-type boundary items in Experiment 6; point-ranges represent the empirical logit and their standard errors

Similar models used in the analysis of the transformed data for fixations on the source (handbag) were used here. Time was modelled on the orthogonal quadratic term with fixed effects of Togetherness (Apart vs. Together) and Boundary-type (Doorway vs. Line). For the by-participants analysis, random effects of participants and participants nested within Togetherness and Boundary type were included on the intercept and slope terms. For the by-items analysis, random effects of item and item nested within Togetherness was included on the intercept and slope terms, however random effects of item nested within Boundary-type were only included on the intercept term, with random effects of Boundary-type included on the slope term (i.e. dropping by-item random slopes for boundary-type). Both of the fixed effects were again modelled using the same deviation-coding structure (Apart and Together were coded as -.5 and .5 respectively, Line-type and Doorway items were coded as -.5 and .5 respectively). As in the analyses used for the transformed fixations on the source (handbag), due to a failure to converge using the maximal random effects structure (Barr et al., 2013), the correlations between random effects were removed (see Barr et al., 2013 for a discussion). For full model examples, see Appendix E.4. Statistical significance was calculated using the normal approximation. Plots of the transformed data and model fits are shown in Figure 4.21. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 4.15.

Table 4.15. By-participants [1] (N=60) and by-items [2] (N=40) parameter estimates for the transformed fixations on the boundary at the onset until the offset of the critical noun region ('book') in Experiment 6

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-3.895	0.063	-61.946	<.001***
Linear	-0.124	0.067	-1.867	.062^{+}
Quadratic	-0.216	0.055	-3.959	<.001***
Togetherness	-0.376	0.082	-4.566	<.001***
Linear: Togetherness	0.149	0.124	1.199	.231
Quadratic: Togetherness	0.009	0.092	0.095	.925
Boundary-type	0.842	0.082	10.240	<.001***
Linear: Boundary-type	-0.052	0.124	-0.422	.673
Quadratic: Boundary-type	0.017	0.092	0.180	.857
Togetherness: Boundary-type	-0.448	0.165	-2.721	.007**
Linear: Togetherness: Boundary-type	0.063	0.248	0.254	.800
Quadratic: Togetherness: Boundary-type	-0.223	0.184	-1.211	.226
By-items [2]				
Intercept	-4.187	0.055	-75.661	<.001***
Linear	-0.356	0.094	-3.781	<.001***
Quadratic	-0.418	0.066	-6.351	<.001***
Togetherness	-0.454	0.107	-4.241	<.001***
Linear: Togetherness	0.333	0.140	2.374	.018*
Quadratic: Togetherness	0.199	0.116	1.720	.086^{+}
Boundary-type	1.611	0.111	14.555	<.001***
Linear: Boundary-type	-0.312	0.188	-1.660	.097^{+}
Quadratic: Boundary-type	-0.015	0.132	-0.112	.911
Togetherness: Boundary-type	-0.268	0.214	-1.250	.211
Linear: Togetherness: Boundary-type	0.322	0.281	1.146	.252
Quadratic: Togetherness: Boundary-type	0.049	0.231	0.211	.833

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 4.15 shows a significant difference between the Apart and Together conditions on the intercept term (p_1<.001; p_2<.001) for transformed fixations on the boundary during the critical noun ('book'), with a larger proportion of transformed fixations on the boundary in the Apart condition when compared to the Together condition. However, there is a non-reliable difference between the Apart and Together conditions on the linear term (p_1=.231; p_2=.018).

Regarding Boundary-type, there is a significant difference between the Doorway-type and Line-type boundary items on the intercept term (p_1<.001; p_2<.001), with a significantly larger proportion of fixations on the boundary when using Doorway-type instead of Line-type boundary items. This discrepancy is readily attributed to the difference in the size and visual saliency of the boundaries (and their interest area sizes) across Boundary-type; the larger the boundary, the more often participants will fixate upon this region. Yet, there is a non-significant difference between the Doorway-type and Line-type boundary items on the linear term (p_1=.673; p_2=.097), suggesting that there is no difference in the rate of access for the boundary regardless of Boundary-type. Interestingly, there is no reliable 2-way interaction between the Togetherness and Boundary-type factors (p_1=.007; p_2=.211), and there is no significant 3-way interaction between Togetherness, Boundary-type, and the linear time term (p_1=.800; p_2=.252).

Taken together these results suggest that both Togetherness and Boundary-type individually contribute to the proportion of fixations on the boundary upon hearing the critical noun (‘book’), with more (transformed) fixations on the boundary in the Apart condition when compared to the Together condition and when using Doorway-type boundaries rather than Line-type boundaries. However, most crucially the Togetherness and Boundary-type factors do not interact (by-subjects). Thus, while using a Doorway-type boundary may be a confounding factor in Experiments 4 and 5 in regards to fixations on the doorway, the effect of condition is unlikely to be driven entirely by using a Doorway-type boundary alone.

4.4.4. Discussion

Experiment 6 explored whether association of the two instantiations of a moved object with the same or separate event models influences accessibility for the updated instantiation of the object on recall. It was predicted that accessibility for the updated instantiation of the object would be reduced when the two instantiations were maintained in separate event models. The critical question was, if this occurs, how is the reduction in accessibility for the updated instantiation manifested? Does the previous instantiation interfere with access for the updated instantiation (i.e. event interference)? Or, are both instantiations simply less accessible (i.e. event competition)? In order to more accurately make inferences about whether any reported effects were due to differences in the event structure across conditions, or due to differences in the visual saliency or interpretation of events as a result of differences in the placement of the boundary across conditions, the present experiment also explored the contribution of the type of boundary (Doorway-type boundaries vs. Line-type boundaries) between the described path of movement for the object.

Focusing primarily upon differences between the conditions throughout the entire time-window of the critical noun, by implementing the above changes (amongst others outlined in section 4.4.2.3), the present experiment found a larger proportion of fixations on the source object in the Together condition when compared to the Apart condition. This effect, however, only held true for those items that included a Doorway-type boundary; when a Line-type boundary was present, the source received a larger proportion of fixations in the Apart condition (vs. the Together condition). One reason for this discrepancy is that, while the Line-type boundary items were included to allow for unimpeded movement of the protagonist across conditions, the divisions between the two locations were too subtle in this case. As a result, it is possible that comprehenders failed to perceive the Line-type boundaries as providing enough of a boundary between locations to necessitate the construction of a new event model following movement of the object from the source to the goal location in the Apart condition. If this is the case, then perhaps event competition does not occur with the Line-type boundary items and as a result the source object is more accessible in this case (vs. Doorway-type boundary items). However, more generally, the source received a larger proportion of fixations when using Line-type boundaries rather than Doorway-type boundaries.

During the critical noun region, there were a larger proportion of fixations on the goal when using Doorway-type boundaries rather than Line-type boundaries. Furthermore, in the Apart condition there were a larger proportion of fixations on the goal for the by-participants analysis, however the opposite was true for the by-items analysis; the goal was fixated on more often in the Together condition when compared to the Apart condition. Despite the same criteria being used in producing the visual scenes for both Doorway-type and Line-type boundary items, it is possible that this discrepancy could reflect differences across items, rather than between conditions, in the by-items analysis. As such, any interaction between Togetherness and Boundary-type might be more informative. However, no reliable interaction was found between the Togetherness and Boundary-type conditions, suggesting that overall, throughout the entire time-window, the effects of both factors were additive and independent. Crucially, regardless of Boundary-type, the boundaries were fixated on more often in the Apart condition than the Together condition, and when using Doorway-type boundary items rather than Line-type boundary items. Again, however, there was no reliable interaction between these two factors.

Focusing instead on the rate of change in the proportion of fixations on the three locations (i.e. source, goal, and boundary), the rate of access for the source is faster in the Apart condition when compared to the Together for Doorway-type boundary items, and in the Together condition when compared to the Apart condition for Line-type boundary items. Again, it is possible that comprehenders failed to construct two event models in the Apart condition with the Line-type boundary items, making the goal more accessible in this case (vs. Doorway-type boundary items). Furthermore, the goal was accessed more rapidly when using Doorway-type items (vs. Line-type items), and was accessed at a faster rate in the Doorway-type boundary items in the Apart condition (vs. the Together condition). Such results potentially reflect comprehenders ‘catching up’ in the Apart condition with Doorway-type boundary items, with a larger proportion of fixations allocated to the source and goal locations as time progresses due to a lower initial level of accessibility for these locations. However, over time, there was no difference in the rate of access for the boundary across the Togetherness and Boundary-type factors.

Taken together, the present findings suggest that both Togetherness and Boundary-type individually contribute to the proportion of fixations on the boundary and goal upon hearing the critical noun (book). Crucially, these factors only interact in regards to the overall proportion of fixations on the source location. Thus, while the Doorway-type boundaries used in Experiments 4 and 5 may have attracted a large proportion of fixations, it is unlikely that the presence of a large boundary between the path of movement of the protagonist in the Apart condition can be the sole factor for the observed results in these experiments.

Returning to the proportion of fixations on each location throughout the entire time-window (i.e. where predictions were made), of most significance in the present experiment is the finding that while boundaries distract attention more often in the Apart condition than the Together condition, and when using Doorway-type boundaries instead of Line-type boundaries, these effects do not reliably interact. Thus, while the proportion of fixations on either the source or goal location may be influenced by the presence or absence of a boundary between them, and thus distracting attention away from either of these locations, the effect of Togetherness is unlikely to be caused solely by differences in low-level visual saliency across conditions, or indeed by any differences in the estimated duration of events described in the discourse (e.g. Coll-Florit & Gennari, 2011) in the Together and Apart condition. (However, these factors might still individually contribute towards differences in viewing behaviour across conditions.) As such, the present experiment cannot rule out the option that any difference in the proportion of fixations on the source and goal locations in Experiments 4 and 5 is driven by differences in event structure (i.e. Togetherness) rather than differences in the visual saliency of the boundary or differences in the simulated actions of the protagonist across conditions.

While the current findings suggest that overall, similarly to Experiment 5, the source location is more accessible in the Together condition when compared to the Apart condition (at least when using Doorway-type boundary items), the results are less clear when interpreting accessibility for the goal location across conditions. One reason for the differences in the direction of effect across conditions in the proportion of fixations on the goal location could lie in the changes made to the current paradigm. In extending the discourse prior to the onset of the critical noun, specifically using an adverbial phrase, and in using no filler items throughout, the discourse may have become too predictable. While an increase in predictability was sought to increase the proportion of fixations on the object-related locations (i.e. source and goal), it is likely that this may have masked any differences in accessibility for the object as a means of differences in event structure; instead of relying upon the event model in order to recall the location of the target object, it is possible that because the target object was always re-mentioned in the final sentence (vs. 50% of mention in Experiments 4 & 5, where filler items were included), the final location associated with it, i.e. the correct location following the discourse, was simply fixated on with little recourse to the event model. Indeed, observing the proportion of fixations on the goal in Figure 4.18, it is clear that there is a steady increase in fixations on the goal prior to the onset of the determiner; an indicator of prediction based on the probability of mention under the current paradigm. Contrasting this with the proportion of fixations on the goal in Experiment 4 (Figure 4.4) and in Experiment 5 (Figure 4.10), it is clear that an increase in fixations starts at a later region in the discourse.

Given the current issues with interpreting the difference in accessibility for the goal across conditions, interpretations into the cause for differences across the conditions in the proportion of fixations on the source and boundary locations are necessary. Focusing first on the source location, because the results of the current experiment replicate those of Experiment 5 for the Doorway-type boundary items (but not the Line-type boundary items) – that the source is more accessible in the Together condition (vs. the Apart condition), it cannot be ruled out that any effect of Togetherness only occurs in Experiment 5 when using Doorway-type boundary items. Here, it is possible that the source is less accessible in the Apart condition (vs. the Together condition) due to the multitude of factors discussed in Section 4.3.4, such as event competition, differences in visual salience, or differences in the estimated duration of events across conditions. Thus, in order to distinguish between these three accounts it is necessary to observe any difference in the proportion of fixations on the boundary across conditions.

In the present experiment, the boundary receives a larger proportion of fixations throughout the entire time-window in the Apart condition when compared to the Together condition, and when using Doorway-type boundary items rather than Line-type boundary items. However, crucially, there is no interaction between these two factors, suggesting that Togetherness and Boundary-type individually contribute to the difference in the proportion of fixations on the doorway. First, why might comprehenders fixate on the doorway more often in the Apart condition, regardless of Boundary-type? In recent research Kamide et al. (2015) have found that comprehenders simulate the path of movement of a character during narrative comprehension. Kamide et al. found that the trajectory of a character along a path of movement is often reflected in visual attention: When a character is described as jumping or crawling from one location to another, attention is allocated to the empty region along the path of movement consistent with the implied height in the movement of the character (e.g. when the character jumps more eye-movements are made in an upward trajectory vs. a downward trajectory when the character crawls). Most importantly to the present experiment, when an obstruction (e.g. a television) was placed between the path of movement, visual attention was directed towards the obstruction – that is, participants fixated on the obstructing object when the simulated state of affairs necessitated movement across it. This might explain why, in the current experiment (and in Experiment 5), participants fixate on the boundary location more often in the Apart condition than the Together condition at a cost to fixations on the source location: If comprehenders simulate the path of movement of the character, and this movement occurs along a boundary, then visual attention must be split between three locations (source, boundary, and goal: i.e. the Apart condition) rather than two (source and goal: i.e. the Together condition). Here, then, we should anticipate a larger proportion of fixations on the boundary at a cost to the proportion of fixations on the source and goal locations; an effect observed in Experiment 5, but also an effect consistent with an event competition account.

For experiments 4, 5, and 6 of the present thesis, a simulation account – in-keeping with that of Kamide et al. (2015) – may be insufficient to explain the observed effects. In the series of experiments conducted by Kamide et al., when an obstruction was placed between the path of movement there was a large increase in the mean proportion of fixations on the boundary and the goal following the onset of the movement verb (e.g. ‘jump’), presumably due to comprehenders simulating the movement of the protagonist from the initial location to the final location, passing by the obstruction. However, in the present experiment (and in Experiments 4 and 5) the slope in the proportion of fixations on the boundary was similar regardless of Togetherness or Boundary-type. Moreover, in the Apart condition when using Doorway-type items there was a consistently larger proportion of fixations allocated to the boundary prior to mention of the actions carried out by the protagonist (i.e. ‘pick up the book’). This could suggest that, rather than comprehenders simulating an action that occurred earlier in the narrative (i.e. walking from one room to another on hearing about a character staying in one location and picking up an object), instead the boundary simply receives a larger proportion of fixations in the Apart condition when compared to the Together condition because the boundary is located more centrally in the visual scene, between the source and goal locations (whereas it is to one side of the screen and not between the source and goal locations in the Together condition). Instead, if any simulation occurs in this final sentence, it would likely involve comprehenders simulating the protagonist looking at the picture and picking up the book; all actions that occur in the final location in both conditions. Thus, on accessing the target object, it is unlikely that participants simulate a more complex or time-consuming set of events in either condition.

In the present series of experiments, it is most likely that the larger proportion of fixations on the boundary in the Apart condition (vs. the Together condition) simply reflects a central fixation bias (Tatler, 2007). Observing the proportion of fixations on the boundary in Figure 4.20, there seems to be a general bias throughout the entire time-window to fixate on the boundary more often in the Apart condition when using Doorway-type items, with no increase in fixations on this area upon hearing the critical noun. Taking into account the hypothesis stated in Section 4.3.4, that a larger proportion of fixations on the boundary in the Apart condition might represent a bias to fixate this (central) region of the visual scene more often, especially when this interest area is particularly large (i.e. Doorway vs. Line-type items), it seems likely that the proportion of fixations on the boundary may not be reflective of language-mediated eye-movements to any particular region. Given that the proportion of fixations on the source and goal locations generally increases upon hearing the critical noun (i.e. source, Figure 4.19; goal, Figure 4.20), yet decreases for the boundary (Figure 4.21), this could indicate that the reduced accessibility for the source in the Apart condition (vs. Together) is not influenced by simulating movement across the boundary, but is rather influenced by other factors. In Experiment 6, the boundary attracted a larger proportion of fixations in the Apart condition (vs. the Together condition) regardless of whether a Doorway-type boundary or Line-type boundary was used. However, across conditions, a larger proportion of fixations were allocated to the Doorway-type boundaries rather than the Line-type boundaries. One explanation for this finding is that Doorway-type boundaries are simply larger and more visually salient than Line-type boundaries (Fecteau & Munoz, 2006), and that, as discussed above, when boundaries are in the centre of the visual scene (i.e. in the Apart condition) more fixations are likely to land within this interest area when compared to cases where boundaries are to one side of the visual scene (i.e. in the Together condition). Such an argument potentially holds more weight given the assumption that comprehenders fail to perceive the two rooms as being two rooms – and thus fail to construct two event models in the Apart condition – for Line-type boundary items.

Due to the lack of a reliable interaction between the Togetherness and Boundary-type factors in regards to fixations on the boundary in the present experiment, it is unlikely that the larger proportion of fixations on the boundary in the Apart condition (vs. the Together condition) is driven by the need to represent longer durative events (e.g. in opening the door to walk to the source location vs. crossing a line) (cf. Coll-Florit & Gennari, 2011). Thus, in the present experiment, it is unlikely that simulating the events described earlier in the narrative, or representing a more complex sequence of events can explain the present findings. Instead, across all Experiments reported here, the most likely explanation for the larger proportion of fixations on the boundary in the Apart condition (vs. the Together condition) is that comprehenders fixate the centre of the visual scene while listening to the discourse, and that fixations on the boundary have little to do with how the location and/or instantiation of the target object is resolved on mention. Rather, the larger proportion of fixations on the boundary, and a lower proportion of fixations on the source location in the Apart condition (vs. Together condition; at least by Doorway-type boundary items) likely reflects difficulty in accessing the target object, possibly due to event competition prior to accessing the target object.

An event competition account would suggest that both instantiations of the object should become less accessible if associated with multiple event models, with a lower a proportion of fixations on the source and goal locations in the Apart condition (vs. the Together condition). However, in the present experiment, as discussed above, the narrative was highly predictable such that comprehenders were aware that the moved object would always be mentioned in the final sentence, as such any fixations on the final location could be driven by comprehenders resolving which instantiation of the object to retrieve prior to mention – as evidenced by the increase in fixations on the goal prior to the onset of the critical noun (e.g. Figure 4.18) – potentially masking any influence of event structure on the accessibility for the goal. While the lower proportion of fixations on the source in the Apart condition (vs. Together condition; at least in the Doorway-type boundary items) is consistent with an event competition account, support for this claim is also dependent upon a lower proportion of fixations on the goal in the Apart condition (vs. the Together condition), which was not observed here. As such, while the results of the present experiment suggest that the presence/absence of a boundary between the path of movement in the narrative has little influence over the proportion of fixations allocated to the source and goal locations, due to the highly predictable narrative any effect of event competition cannot confidently be accepted here. Because of these factors, caution must be applied when evaluating the influence of the Boundary-type on the findings discussed in Experiments 4 and 5. Improvements to the current paradigm would necessarily involve rotating across Togetherness and Boundary-type orthogonally within items, allowing for more accurate interpretations of the results in light of the various explanations discussed in this Chapter. Presently, it is important to consider the findings of the current experiment in light of those of Experiments 4 and 5 to account for the drawbacks of the current experimental paradigm. As such, Section 4.5 will discuss possible interpretations for the current set of experiments, with suggestions for future research to differentiate between the possible factors at play.

4.5. General Discussion

Experiments 4, 5, and 6 presented discourses describing an object moving from one location to another in the context of visual scenes which necessitated this movement to be either across a boundary (i.e. Apart condition) or not (i.e. Together condition). Under the assumptions of the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012), when an object encounters a change in space the working event model must be updated to accommodate this change: When an object moves across a boundary (e.g. a doorway; Apart condition), a new event model is constructed to represent the new location and its contents, whereas if movement occurs within one room (i.e. not across a doorway; Together condition), the working event model is transformed to reflect the change in location for the object. Thus, the object can be represented in two event models or one event model respectively. While the Event Horizon model predicts that interference occurs when accessing an object associated with multiple event models (Radvansky, 2012), it is presently unclear what causes this interference: On access for the moved object represented in two event models, do the two instantiations of the object interfere with one another (i.e. event interference), or do they compete prior to access in a ‘winner-takes-all’ sense (i.e. event competition)? The experiments reported here intended to explore which mechanism of interference is at play by observing the proportion of fixations on the initial and final locations associated with the moved object across conditions on re-mention for the object. It was predicted that when the source and goal were in separate event models (vs. the same event model), if event interference was at play then the source should receive a larger proportion of fixations at a cost to fixations on the goal, whereas if event competition was at play then either the goal alone, or the source and goal should receive a lower proportion of fixations.

In Experiment 4, participants took part in a concurrent viewing and listening paradigm. During the critical noun (i.e. on mention for the moved object) there was no difference between the Together and Apart conditions in the proportion of fixations on the source object either throughout the entire time-window or as time went on. However, the goal received a larger proportion of fixations throughout the entire time-window in the Together condition when compared to the Apart condition (with no difference in the rate of access for the goal between the two conditions). Here, the question is, if the goal is less accessible in the Apart condition (vs. the Together condition) but there is no difference in the accessibility for the source across conditions, where else are comprehenders looking on hearing the name of the moved object? One location is the boundary; this location received a larger proportion of fixations throughout the entire time-window in the Apart condition when compared to the Together condition (but with no difference across conditions in the proportion of fixations here as time goes on).

While the choice of using a concurrent viewing paradigm for Experiment 4 was made primarily to afford the best opportunity to detect any difference in accessibility for the two instantiations of the object driven by differences in event structure across the two conditions (i.e. compared to low fixation proportions from the blank-screen paradigm: cf. Experiments 1 and 2 of the present thesis), by depicting the object in its initial location and in using a concurrent viewing paradigm it is likely that low-level referential processing occurred (i.e. looking at the book (source) on hearing ‘book’), masking any differences in accessibility for the initial instantiation of the object across conditions. Thus, in Experiment 4 it is unclear whether the goal is less accessible in the Apart condition (vs. the Together condition) because the two event models compete prior to access such that only the final instantiation of the object is less accessible (i.e. event competition), because the two event models compete prior to access such that the initial and final instantiation of the object is less accessible (i.e. event competition), or whether the final instantiation of the object is less accessible because the initial instantiation is more accessible (i.e. event interference).

Alternatively, is possible that the lower proportion of fixations on the goal in the Apart condition (vs. the Together condition) in Experiment 4 can be explained by a larger proportion of fixations on the boundary in the Apart condition (vs. the Together condition), with fixations on the boundary being higher in the Apart condition when compared to the Together condition for four main reasons aside from differences in event structure: (1) being located more centrally in the visual scene, it is possible that the boundary was more visually salient (for a discussion, see Fecteau & Munoz, 2006) in the Apart condition when compared to the Together condition, attracting more fixations on the boundary in this case at a cost to fixations on the goal; (2) being located more centrally in the visual scene, it is also possible that more fixations landed on the boundary in the Apart condition (vs. the Together condition) due to a central fixation bias (Tatler, 2007), with fixations here not coming at a cost to fixations on the source or goal; (3) it is possible that comprehenders represent a more complex sequence of events in the Apart condition (vs. the Together condition), simulating, for example, opening up and walking through the doorway (e.g. Coll-Florit & Gennari, 2011). This need to represent a more complex sequence of events could increase processing costs prior to accessing the target object, reducing accessibility for this on mention; (4) If eye-movement behaviour reflects simulation of the events in the narrative, simulating the movement of the protagonist necessitates moving across a boundary in the Apart condition, but not in the Together condition. As such, visual attention must be divided between three locations in the Apart condition (i.e. source, boundary, goal), but only two locations in the Together condition (i.e. source, goal), causing a larger proportion of fixations on the boundary and a lower proportion of fixations on the source and goal in the Apart condition when compared to the Together condition (e.g. Kamide et al., 2015). While in this case we should predict a decrease in the proportion of fixations on the source as well as the goal it is possible that, again, low-level referential processing could have masked any difference here. Thus, in order to distinguish between an event competition account and the four accounts described here, Experiment 5 used the same paradigm as in Experiment 4, but replaced the visual scene with a blank-screen prior to the onset of the discourse (e.g. Altmann, 2004; Spivey & Geng, 2001), controlling for differences in accessibility for the source, boundary, and goal driven by low-level visual properties in the display.

Experiment 5 found that, during the critical noun (i.e. on re-mention of the target object), there was a larger proportion of fixations on the source and goal objects throughout the entire time-window in the Together condition when compared to the Apart condition. As time went on, there was also a faster increase in the proportion of fixations on the source in the Apart condition (vs. the Together condition), while the inverse was true for the goal. Again, as in Experiment 4, the boundary received a larger proportion of fixations in the Apart condition when compared to the Together condition (with no difference between conditions in the rate of fixations on this location). Considering the findings of Experiment 5 in light of Experiment 4, while both experiments showed that the goal received a larger proportion of fixations in the Together condition when compared to the Apart condition throughout the entire time-window, only Experiment 5 found that the source also received a larger proportion of fixations in the Together condition (vs. the Apart condition). Although this discrepancy could be attributed to the removal of the source object from the visual scene – and thus removing low-level referential processing and its masking of effects – it is also possible that these findings could be accounted for by the relative size of the difference between the two conditions in the proportion of fixations on the boundary across the two experiments: Both Experiment 4 and 5 found a larger proportion of fixations on the boundary in the Apart condition than the Together condition throughout the entire time-window, but this effect was more than twice as large in Experiment 5 than Experiment 4. As such, it is possible that the boundary simply attracted more attention in Experiment 5 than Experiment 4, thus distracting attention from the source location more often in this case.

While using the (blank-screen) paradigm in Experiment 5 means that it is unlikely that fixations on the location associated with the boundary are affected by differences in the visual salience of the boundary (i.e. explanation 1), it is still possible that this location attracted more attention in the Apart condition (vs. the Together condition) simply due to a central fixation bias (Tatler, 2007) (i.e. explanation 2), in which the boundary was located more centrally in the visual scene in the Apart condition than the Together condition, and thus fixations here do not detract from the source or goal locations. Alternatively, the two simulation accounts discussed above could explain the observed effects; it is possible that even in the blank-screen paradigm comprehenders simulate the movement of the protagonist, necessitating movement across a boundary; attracting attention to this location at a cost to other locations (e.g. Kamide et al., 2015), or necessitating the representation of a more complex sequence of events, causing interference on access for the target object due to increased processing costs.

Although observing the rate of access for the source, goal, and boundary locations may have provided some insight into the underlying processes occurring when accessing the target object (in its different locations/instantiations), across Experiments 4 and 5 (and further, in Experiment 6) there was little accord in the rate of access for the objects across these experiments. Moreover, the rate of access for an object is difficult to interpret theoretically with the current literature. As such, a comparison of the intercept values (i.e. overall accessibility of the objects) across conditions is most useful in interpreting the present findings. With this in mind, Experiment 6 was designed to distinguish between the above explanations for the current findings.

Experiment 6 aimed to address which explanations outlined above can best explain the findings of Experiment 5, asking whether a simulation account (i.e. explanations 3 and 4) or a central fixation bias (Tatler, 2007) (i.e. explanation 2) can best explain the observed results. In order to address the above explanations for the findings of Experiment 5, in Experiment 6 two types of items were used; those depicting two rooms separated by a Doorway (i.e. Doorway-type boundary items) and those depicting two rooms separated by a Line (i.e. Line-type boundary items). If simulating a more complex sequence of events (i.e. explanation 3) is the cause of the results in Experiment 5, then we should predict similar effects in Experiment 6 only when using Doorway-type boundaries that necessitate a more complex sequence of events (i.e. opening up and walking through the doorway), and not when using Line-type boundary items. If, however, simulating movement from one location to another results in comprehenders splitting attention between 3 locations in the Apart condition (vs. 2 in the Together condition) (i.e. explanation 4), then we should predict similar effects to Experiment 5 regardless of Boundary-type (but perhaps with a smaller effect size in the Line-type boundary items). Finally, if a central fixation bias can account for the observed effects in Experiment 5, then we should predict similar effects to those reported in Experiment 5 for fixations on the source, goal, and boundary in the Apart and Together conditions, only with a smaller effect size in the Line-type boundary items when compared to the Doorway-type boundary items. While explanations 2 and 4 predict similar findings in Experiment 6, it is unlikely that explanation 4 can account for the findings of Experiment 5 given that the movement of the protagonist occurred at an earlier point prior to mention for the target object, and as such re-simulating such movement would be unnecessary.

In order to obtain a larger proportion of fixations on each location within the visual scene to best observe any effect of the experimental conditions, a concurrent viewing and listening paradigm was employed in Experiment 6, but to remove low-level referential processing for the source, both the source and goal locations were replaced with containers and the narrative described an object moving between these two locations; a method that has been shown to allow for access to both the initial and final instantiation of a moved object in previous research (Kukona et al., 2014). Moreover, the final sentence was lengthened – including an adverbial phrase before re-mention of the target object – and no filler items were included in the testing session in an attempt to telegraph the mention of the target object such that eye-movements to regions other than those associated with the target object (e.g. the boundary) would be reduced.

Experiment 6 showed that, throughout the entire time-window, the source object received a larger proportion of fixations in the Together condition when compared to the Apart condition, and when using Line-type boundaries rather than Doorway-type boundaries. However, an interaction was found between these two factors in which the source received a larger proportion of fixations in the Together condition (vs. the Apart condition) for Doorway-type boundary items, and in the Apart condition (vs. the Together condition) for the Line-type boundary items (with opposite directions of effect over time). For the goal, the results were less clear. Throughout the entire time-window (and over time), the goal received a larger proportion of fixations when using Doorway-type boundaries rather than Line-type boundaries. However, while there were a larger proportion of fixations here in the Apart condition (vs. the Together condition) by participants, the inverse was true by items, likely reflecting differences in what is apparent to each model (discussed further in Section 4.4.3.2). Over time, the rate of increase in the proportion of fixations on the goal was faster in the Together condition (vs. the Apart condition) when using Doorway-type items only. Finally, the boundary received a larger proportion of fixations over the entire time-window in the Apart condition (vs. the Together condition), and when using Doorway-type boundary items (vs. Line-type boundary items). Yet, there was no interaction between these two factors, suggesting that Togetherness and Boundary-type individually contribute to the proportion of fixations on the boundary.

Why then, do the results of Experiments 5 and 6 differ so markedly? One reason for the difference in the rate of access for the source and goal locations in Experiments 5 and 6, and for the lack of any reliable difference in the proportion of fixations on the goal throughout the entire time-window in Experiment 6 lies in the failure to include any filler items throughout in this experiment, resulting in highly predictable narratives. In Experiment 6, prediction seems to occur with a steady increase in the proportion of fixations on the source and goal locations before mention of the target object – an effect not present in Experiments 4 and 5. By including filler items, future experiments will be able to address whether fixations on these regions are guided by the event model or by prediction based on the probability of mention for the upcoming referent. Yet, interpreting the results of Experiment 6 in light of Experiments 4 and 5, it is clear that, throughout the entire time-window, and across all experiments, the boundary receives a larger proportion of fixations in the Apart condition when compared to the Together condition. In Experiments 5 and 6, this larger proportion of fixations on the boundary in the Apart condition (vs. Together) is associated with a lower proportion of fixations on the source object, as fixations here are unlikely to be driven by low-level referential processing (cf. Experiment 4). Throughout the entire time-window, Experiments 4 and 5 reported a lower proportion of fixations on the goal in the Apart condition when compared to the Together condition. While this was also true in Experiment 6 for the by-items analysis, the inverse was true for the by-participants analysis. However, in this experiment, because the items used different Boundary-types, it is likely that this may have influenced the outcomes of both of the analyses; the by-participants model is blind to the fact that items do not appear in both boundary conditions. As such, focusing primarily upon the by-items analysis may be more informative here when interpreting main effects. In doing so, the results of Experiment 6 more closely resemble those of Experiments 4 and 5; throughout the entire time-window, there are a larger proportion of fixations on the goal in the Together condition when compared to the Apart condition.

Taking into account the findings of Experiments 4-6 and addressing the implications of their findings provides the best opportunity to understand the locus of the effects reported in these experiments. While Experiment 6 suggests that large, Doorway-type boundaries are more likely to attract attention than smaller, Line-type boundaries, the boundary still attracts more attention in the Apart condition when compared to the Together condition regardless of boundary-type used. As such, this suggests that the effect of Togetherness is likely not driven solely by simulation of more complex or time-consuming events in the Apart condition (vs. Together) (i.e. explanation 3) (Coll-Florit & Gennari, 2011). Moreover, while it is possible that comprehenders simulate the initial movement of the object from the source to the goal location, necessitating movement across the boundary in the Apart condition (but not in the Together condition), and thus attracting attention to the boundary at a cost to the source and goal (e.g. Kamide et al., 2015) (i.e. explanation 4), as noted above it is unlikely that comprehenders would simulate this action as it occurred so early in the narrative; instead, opting to simulate the actions of the protagonist in the final location on mention (i.e. looking at the distractor before picking up the target object). Also, while Experiment 5 showed that the source and goal received a lower proportion of fixations (and the boundary received a larger proportion of fixations) in the Apart condition (vs. the Together condition) when using the blank-screen paradigm, it is unlikely that the present findings can be explained in terms of differences in visual saliency across conditions (i.e. explanation 1).

Given the above explanations, it is likely that the boundary receives a larger proportion of fixations in the Apart condition (vs. the Together condition) because the boundary (and its interest area) is located more centrally within the visual scene, and that fixations here simply reflect a central fixation bias (Tatler, 2007), with little effect on the fixations on the source and goal locations. Furthermore, while Experiment 4 suffered from confounds associated with low-level referential processing in the proportion of fixations on the source, for the goal the pattern of results is similar to that of Experiment 5. Also, while Experiment 6 suffered from using highly predictable narratives, potentially masking any effect on the goal, the pattern of results for the source is also similar to that of Experiment 5 (at least when using Doorway-type boundary items). Thus, together, it seems likely that the most reliable finding across Experiments 4-6 is that the source and goal are less accessible throughout the entire time-window on mention for the target. Given these findings, it is likely that the need to maintain and select between multiple event models prior to accessing the target in the Apart condition (vs one event model; i.e. the Together condition) is simply more cognitively demanding, reducing accessibility for both instantiations of the object in line with an event competition account. That is, event competition is likely to be at play throughout Experiments 4-6.

Further studies are necessary in order to confidently accept the assertion that the present findings are caused by event competition, necessitating the usage of the same visual scenes across conditions to rule out other explanations based around differences in the simulated events and/or saliency of the visual scenes across conditions. One way to observe the reduced accessibility for the initial and final instantiations of a moved object when they are held in separate event models (vs. the same event model) is to use shifts in time as a means to segment the two event models. Given minimal shifts in time between the discourse events, it is likely that the sequence of events and the objects mentioned will be contained within one event model. Whereas when a large shift in the discourse events occurs, it is likely that this shift constitutes an event boundary, necessitating separation of the pre- and post- shift events, and objects, into separate event models (Rinck et al., 1998; Zwaan et al., 1995; Zwaan & Radvansky, 1998). While this inherently comes with the confound of a difference across conditions in the time and/or complexity of the simulated events (Coll-Florit & Gennari, 2011), this would help to separate the present results from explanations derived from differences in the visual scenes across conditions.

Evaluating the present findings in light of the previous experiments in this thesis, it is apparent that when a spatial shift is encountered during discourse comprehension this reduces accessibility for probed-for information. Whether the target is something that was relevant prior to the shift in space (Experiment 2), following a shift in space

(Experiments 4, 5, and 6), or either one of the two (Experiment 3), a spatial shift is associated with reduced accessibility for the target object. These findings are consistent with previous research (Morrow et al., 1989; Radvansky & Copeland, 2006; Radvansky et al., 2011; Rinck et al., 1998, 1997) and theories (Radvansky & Zacks, 2011, 2014; Radvansky, 2012) on event cognition. However, the present set of experiments are unique in showing that when an object encounters a change in space across an event boundary, it is likely that the reduced accessibility for the object is caused by competition between the two event models containing the separate instantiations for the object. Indeed, as the previous experiments in this thesis highlight that maintaining multiple event models is associated with a reduction in accessibility for a target object (e.g. Experiments 2 and 3), it is likely that the present set of experiments adhere to a similar principle. Here, competition between the event models is likely the cause of reduced accessibility for the two instantiations of the moved object in the Apart condition (vs. the Together condition) due to the need to maintain and select between two relevant event models associated with the target object. Indeed, previous research has shown that information maintained in locations that are relevant to the goals of the protagonist tends to be more accessible than information maintained in irrelevant locations (Morrow et al., 1989; Rapp et al., 2006). This would suggest that when a relevant piece of information is maintained across two separate event models, conflict – or competition – should occur.

While there are several drawbacks with the current paradigm, such that in the present set of experiments it is possible that there is an imbalance in the number of event models maintained across conditions (i.e. Apart, 2 event models; Together, 1 event model), and the present series of experiments did not control for the saliency of the visual scenes across conditions during comprehension (cf. Experiment 5), for differences in the simulated time-course and/or complexity of events across conditions, or for the predictability of the discourse in the case of Experiment 6, it seems likely that given the concordance with previous experiments in the literature (Radvansky & Copeland, 2006; Radvansky et al., 2011), previous experiments in the present thesis (e.g. Experiments 2 and 3), and theory (Radvansky & Zacks, 2011, 2014; Radvansky, 2012), that the reduction in accessibility for the two instantiations of the object in the Apart condition (vs. Together) is driven by competition between the two relevant event models associated with the target object.

The implications from the present series of experiments are that event competition should only occur when an object is associated with multiple event models, as the need to select between two relevant event models reduces accessibility for the target in this case (vs. cases where the object is maintained in one event model); essentially the two instantiations of the same object are the target and competitor in this case. However, according to the Event Horizon model, if a target and competitor are different objects, we should predict more competition when the target and competitor are maintained in the same event model, as the competitor is both not suppressed and is foregrounded when accessing the event model associated with the target. Following from this, when the target and competitor are maintained in separate event models then no competition should occur as the event model containing the competitor is irrelevant to the task at hand (i.e. retrieving the target). In order to observe whether competition in the present set of experiments is driven primarily by event competition (i.e. the need to select between multiple relevant event models prior to accessing the target), Experiment 7 aims to explore how event structure can modulate competition between two different objects, using a target and a semantically-related competitor rather than two instantiations of the same object, as targets and competitors. If competition occurs only between event models that are relevant to the target object, holding the target and competitor in separate event models should reduce the amount of competition between the two objects when compared to holding the two in the same event model. In this case, whether or not the competitor is in the same or separate event model to the target should be the defining feature for semantic competition. Thus, it is predicted that event competition only occurs during competitive retrieval for a target (i.e. when more than one instantiation of a target is maintained), but not during non-competitive retrieval (i.e. when only one instantiation of the target is maintained).

Despite the drawbacks of the current series of experiments, it has been shown that regardless of whether the target object is foregrounded or not, a spatial shift reduces accessibility for the target. Furthermore, it has been shown that this is associated with reduced accessibility for both instantiations of the target, likely through competition between the two event models associated with the target. Indeed, because the updated instantiation of the object is equally foregrounded across conditions, the reduced accessibility for the updated instantiation of the target object in the Apart condition (vs. the Together condition) likely highlights that event competition outweighs foregrounding in the present set of experiments. Experiment 7 aims to build upon the present set of experiments, exploring whether the event competition mechanism outlined and observed here only occurs during competitive retrieval, asking whether segmenting a target and competitor in separate event models acts to reduce competition during non-competitive retrieval.

Chapter 5

Spatial Effects on Semantic Competition in Discourse Processing

5.1. Experiment 7

5.1.1. Introduction

The previous experiments in this thesis were broadly designed to address whether a change in space within a narrative reduces accessibility for a target object during discourse processing. In showing that categorical shifts by a character and/or target object causes a reduction in accessibility for the target during passive listening tasks, the series of experiments so far outlined in this thesis support the notion that event structure largely influences the degree to which information can be accessed during language processing. Specifically, these results lend support to two principles outlined in the framework of the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012): (a) that event segmentation occurs at event boundaries according to the principles of EST (see Radvansky & Zacks, 2011) and requires cognitive effort, and (b) that retrieval interference occurs when accessing information maintained in multiple event models during competitive access (i.e. in Experiments 4 and 5), likely due to event competition. That is, competition occurs when more than one event model is relevant to the target object due to the need to select between the relevant event models prior to accessing the target. As such, we might predict that if the target and competitor are separate objects then no event competition should occur when the target and competitor are maintained in different event models (vs. one event model) as only one event model is relevant to the target regardless of the location of the competitor. The present experiment aims to address this claim.

The present experiment also aims to address a third point, which was unsupported in Experiment 3; that information in the working (foregrounded) event model is most highly accessible. Experiment 3 failed to support the notion that, regardless of a spatial shift, objects in the foregrounded event model are most accessible (vs. objects in backgrounded event models). While the literature surrounding this phenomenon is wide-ranging and robust (e.g. Glenberg, Meyer, & Lindem, 1987; Morrow, Bower, & Greenspan, 1989; Morrow, Greenspan, & Bower, 1987; Rinck & Bower, 1995) one reason for the failure to replicate such results in Experiment 3, amongst others, may be attributed to the narrative drawing particular attention to both locations immediately prior to re-mention of the target. In doing so, this may have made both locations highly accessible prior to accessing the target, negating any effects of foregrounding in line with those established in prior research. Regardless of whether any effect of foregrounding, in the terms outlined by Glenberg et al. (1987), was obtained in

Experiment 3, an interpretation of why any effect of foregrounding arises in the current literature is also presently unsatisfactory. The present experiment thus aims to address not only how event segmentation can modulate competition when the target and competitor are different objects, but also aims to address the role of foregrounding in this case.

While previous research has shown that a target is more accessible when maintained in the working event model (vs. previous models) (e.g. Bower & Rinck, 2001; Glenberg et al., 1987; Morrow et al., 1987), by using accessibility for the target itself – either by anaphoric reference during reading tasks, or in response-probe tasks – as a measure of the preferential bias in accessibility for information in the working event models (vs. others), this causes a ‘double-penalisation’ in regards to access for information outside of the working event model. When accessing a target outside of the working event model, not only will this target be generally less accessible than if it was foregrounded prior to mention, but a shift in attention from the working event model to the one associated with the target is required in order to access the target. This shift in attention would necessitate an increase in processing effort, further reducing accessibility for the target (Radvansky & Zacks, 2011). Yet, when attention is shifted to a backgrounded event model containing the target, this results in a privileged level of accessibility for information in this newly foregrounded event model (Radvansky & Zacks, 2014; Radvansky, 2012). Thus, regardless of whether the target is initially maintained in a backgrounded or foregrounded event model, information in the same location as the target becomes more accessible on access; this event model becomes foregrounded. In order to observe the effect of foregrounding irrespective of a cost to switching focus, foregrounding must be measured by how accessible one piece of information (e.g. an object) is on mention for the target when in the same location as the target and when in a different location to the target. Presumably, information aside from the target should be most accessible when accessing the target, and by necessity, the event model containing the target. Whereas this information should be less accessible when in a different event model to the target as attention should be focused on the event model containing the target. In this sense, a measure of accessibility for this second piece of information would provide a means to evaluate foregrounding effects divorced from a cost to shifting attention to a new event model.

Returning to the results of Experiments 4 and 5 (and partially, Experiment 6), this series of experiments has provided evidence in support of event competition as the mechanism for interference when accessing information represented across multiple event models. The implications of this mechanism of competition is that event models, and the information maintained within them, should only be accessed when relevant to a target. For example, in cases where a target and competitor are two instantiations of the same object (e.g. following the movement of an object from one room to another in Experiments 4-6), retrieval interference occurs due to competition between the event models associated with the object (Radvansky & Copeland, 2006; Radvansky et al., 2011; Radvansky, 1999). Thus, event models are evaluated in terms of their relevance to the target prior to access. In cases where a target and competitor are two instantiations of the same object (e.g. Experiments 4-6), the two objects share similar properties, including their name. Thus, on mention for the target, this causes conflict; multiple event models must be selected between (and compete) prior to access for the correct instantiation of the target. However, if only one event model is relevant to the target, competition between event models cannot occur. Thus, if the target and competitor are different objects, then on mention for the target event competition should not occur. Instead, only the event model containing the target should be accessed without interference, because only one event model is relevant to the target. Thus, in cases where the target and competitor are in the same event model, it is likely that the competitor will become more accessible as a result of foregrounding for this event model. Unlike in Experiments 4-6, following Event Segmentation Theory (Radvansky et al., 2011; Zacks et al., 2009) there is no need to update and suppress the competitor as no movement event occurs to establish a new representation of the competitor. As such when it is in the same event model as the target it will be more accessible than if it were in a different event model. In cases where the target and competitor are in different event models, it is unlikely that the event model containing the competitor will also be accessed when accessing the target. As a result, it is likely that the competitor will become less accessible in this instance. In order to address this assumption and to more accurately address foregrounding without recourse for a spatial shift, the present experiment aims to manipulate how event structure can influence accessibility for a target when in the same location or when in a different location to a different-object competitor.

Following an outline of the present experiment and rationale for the study, a discussion of the justification for using semantic competitors and applying other restrictions to the experimental stimuli will follow. In order to explore the issues described above, the present experiment will manipulate whether a target and competitor are Together, in the same event model, or Apart, in separate event models within the discourse. However, unlike in Experiments 4-6, the target and competitor are two different objects; in this case, two semantically-related objects – as determined by Latent Semantic Analysis (LSA) co-occurrences (see Landauer & Dumais, 1997; Landauer, Foltz, & Laham, 1998). Similarly to Experiment 3, a quadrant display was used to show four objects that could be manipulated in terms of their locations within the discourse. Thirty-two experimental quadrants (see Figure 5.1) were paired with spoken discourses consisting of three sentences. There were two sentential conditions (1-2a, b; 1-2c, d) that correspond to the four manipulations of sentence group 1 (1-2a, b, c, d) presented in Example 5.1.

Example 5.1. An example of the linguistic stimuli used in Experiment 7

(1-2a) The lock and the key are in the cafeteria. The ball and the melon are in the parlour.

(1-2b) The ball and the melon are in the cafeteria. The lock and the key are in the parlour.

(1-2c) The lock and the melon are in the cafeteria. The ball and the key are in the parlour.

(1-2d) The ball and the key are in the cafeteria. The lock and the melon are in the parlour.

(3) It seems that the lock is very old.

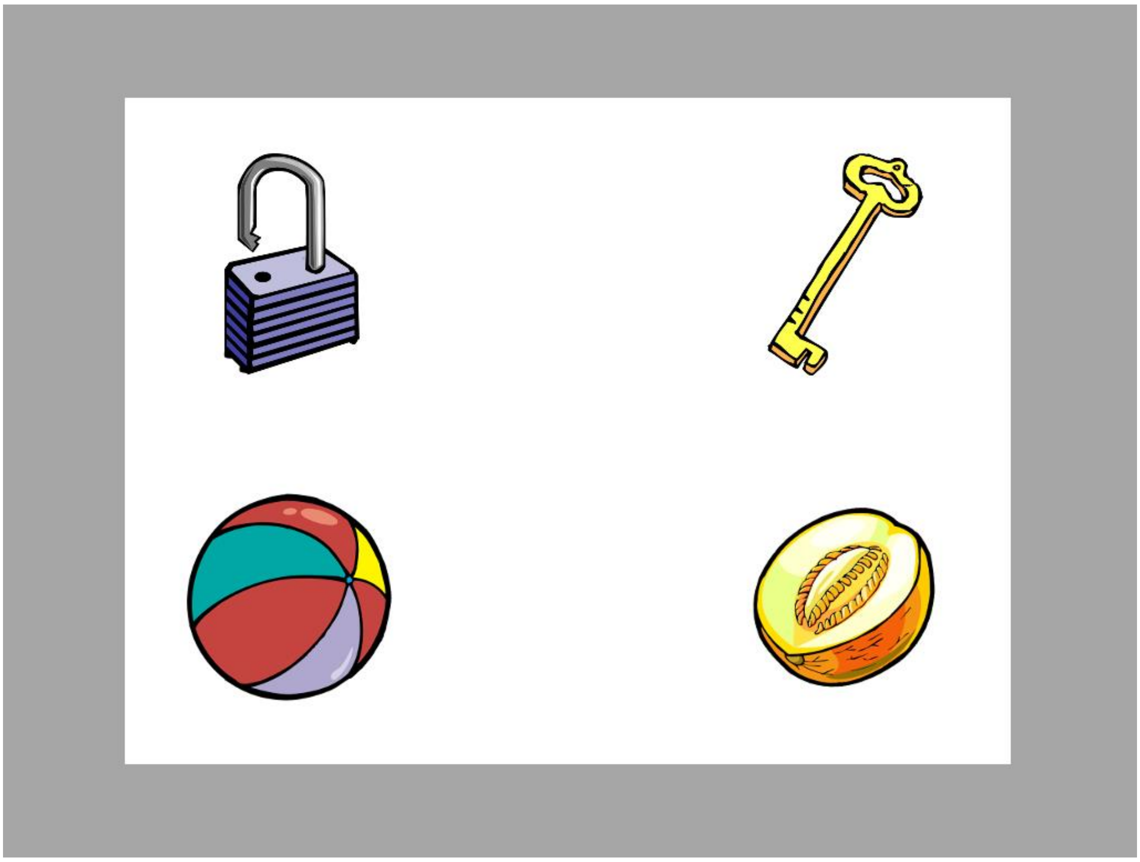


Figure 5.1. Example visual scene accompanying spoken sentences, e.g. Example 5.1

The experimental conditions pertained to whether the target object (lock) and the semantically-related competitor (key) were located in the same (1-2a, b) or separate (1-2c, d) rooms. Thus, in 1-2a and 1-2b, the target and competitor are maintained in the same event model, whereas in 1-2c and 1-2d, they are maintained in separate event models. In order to control for recency of mention for the target and competitor, the target object was mentioned in either the first (1-2a, c) or second sentence (1-2b, d) across conditions. Moreover, to ensure that any potential differences across conditions were driven by association with the same or separate locations and not by differences in the priming of the target/competitor when they are mentioned in particular locations (e.g. cafeteria, parlour), the two conditions were rotated across each location; the lock and key were mentioned as being together in the cafeteria in one case (1-2a), and the parlour in the next (1-2b). When separated, the lock was mentioned in the cafeteria in one case (1-2c), and the parlour in another (1-2d), with the inverse occurring for the key. Following (1-2), (3) re-mentioned the target object (e.g. lock) initially mentioned in (1-2). Across items, each object was mentioned first, second, third, or fourth across sentences 1 and 2 an equal number of times. Similarly to Experiments 3-6, in the present experiment both conditions will establish an equal number of event models in the narrative such that any difference in accessibility for the target and/or competitor cannot be attributed to a mismatch in the number of event models maintained in memory (cf. Experiments 1-2). Following the principles of the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012), when accessing the target on mention no competition will occur between event models as only one event model is relevant to the target. Furthermore, when accessing the event model containing the target, this event model will become foregrounded (if it was not already), causing all information maintained within this event model to become more accessible and all information maintained in other (backgrounded) event models to become less accessible. Thus, if the competitor is maintained in the same event model as the target it will be more accessible than if it is maintained in a different event model to the target. In effect, then, maintaining a target and competitor in separate event models will act to improve accessibility for the target by reducing accessibility for the competitor.

The notion that maintaining information across multiple event models can improve memory for said information has recently been explored by Pettijohn, Thompson, Tamplin, Krawietz, and Radvansky (2016). In the first two of four experiments, participants were given a word list to memorise. In one condition, participants could memorise both halves of the list in one room. In another condition, participants could memorise one half of the word list in one room and the other half in another. Pettijohn et al. (2016) hypothesised that in doing so, participants in the first condition would maintain both halves of the word list in one event model, and in the second condition participants would maintain both halves of the word list in two, separate event models. When both halves of the word list were memorised across two locations, there was a general benefit to memory for information on the whole word list during a free recall task. Pettijohn et al. concluded that when both halves were memorised across two locations this memory benefit was likely due to the event models providing structure to each half of the list and reducing the amount of competitive information maintained within each event model. The findings of Pettijohn et al. highlight how event segmentation can positively affect accessibility for information maintained within event models. This stands in stark contrast to the majority of research evaluating the role of event structure on memory that show negative consequences to event segmentation (c.f. Glenberg et al., 1987; Morrow et al., 1987; Radvansky & Copeland, 2006; Radvansky et al., 2011; Rinck & Bower, 1995, 2000; Rinck et al., 1997; Speer et al., 2007). While Pettijohn et al. explored how event structure can improve memory for information represented across multiple event models, the present experiment aims to explore how accessibility for a target can be improved by manipulating whether a competitive source of information is maintained in a separate event model to the target. In this way, the present experiment builds upon the conclusions of Pettijohn et al. (2016), that manipulation of competitive sources of information can improve memory. In their experiment, memory was improved for all items on the list by reducing the number of competitors maintained within each event model, whereas the present experiment aims to remove particularly competitive sources of information from the event model associated with the target in order to improve accessibility for the target only. Thus, in both experiments, distributing competitive sources of information across event models can act to improve accessibility for information.

In assessing the effect of foregrounding divorced from spatial shifts (i.e. whether or not the competitor is in the same event model as the target), and the superiority of accessibility for information stored across multiple event models in non-competitive retrieval, the present experiment will test the accuracy of two of the five principles of the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) that have not been confirmed in the present thesis. While the series of experiments reported in this thesis assume that the first principle, that streams of activity are segmented into separate event models at event boundaries, holds true, the notion that we construct a causal network of events that can influence retrieval is beyond the scope of this thesis. However, Experiments 4-6 lend support to the notion that retrieval interference occurs during competitive retrieval for information stored across multiple event models, but goes further in providing evidence in support of a potential mechanism as to why this occurs. Specifically, Experiments 4-6 support the notion that those event models that are relevant to the target are considered on access for the correct instantiation of a target. When the target is represented across multiple event models, interference occurs when attempting to access the correct (updated) instantiation of the target. This suggests that during non-competitive retrieval, i.e. when a target is associated with only one event model, only the event model associated with the target will be considered on access. This supplies an avenue in which to provide evidence for the superior accessibility of information in the working event model vs. backgrounded event models; if a target is mentioned, the event model containing it will be accessed, causing all information within this event model to become more accessible. Thus, if the competitor is in the same event model as the target, it should presumably be more accessible than if it were in a different event model to the target. Not only this, but such findings would provide evidence that storing information across multiple event models during non-competitive retrieval can act to improve accessibility for the target, albeit in a task where not all information is required from all event models (c.f. Pettijohn et al., 2016). In this way, the present experiment aims to explore how event structure can improve accessibility for a target by reducing accessibility for a competitor.

In order to test the aims set out above, the present experiment is beholden to a number of restrictions in its design. Here, it is predicted that on mention of a target, the event model containing the target will become foregrounded, making other sources of information within this event model more accessible and sources of information outside of this event model less accessible. In order to test whether this holds true irrespective of a shift in attention from one event model to another (i.e. in order to access a target from a backgrounded event model), it is necessary to identify a source of information that can naturally compete with a target while being a separate object to the target (i.e. not another instantiation of the target, such as in Experiments 4-6). This is necessary to avoid ambiguity for what should be accessed on mention. In cases where the target and competitor are two instantiations of the same object, the name of the target is also the name of the competitor. Thus, when maintained in separate event models, competition occurs as the name of the target prompts for access of both instantiations and both models. If, however, the target is a different object to the competitor, there can be no ambiguity to what the name of the target refers to, thus only one event model will be accessed. In order to observe an effect of foregrounding, in which maintaining the competitor in the same event model as the target improves accessibility for the competitor and maintaining the competitor in a different event model to the target reduces accessibility for the competitor, it is necessary to use a competitor that naturally competes with the target during language processing tasks. Similarly to the previous experiments in this thesis, the target and competitor are inanimate objects that can conceivably appear in various locations, allowing for differences in event structure across conditions to be established by varying the locations of the objects within the narrative. Moreover, in using eye-tracking to establish accessibility for referents linked to objects displayed in visual scenes, visually-distinct objects must be used. With these constraints in mind, a wealth of research in language processing provides potential candidates, and potential restrictions, for objects that compete with one-another during lexical access.

In order to identify a spoken word, we must select between a number of potential candidates as the word unfolds. In cases where words share similar onset sounds (henceforth, cohorts), these words become partially activated as the word unfolds (e.g. hearing /bi/ in ‘beaker’ can partially activate the phonologically similar ‘beetle’). In continuous activation models (e.g. McClelland & Elman, 1986), it is also assumed that this lexical access occurs throughout processing, such that words sharing similar offset sounds, i.e. rhyming words, partially activate other candidates (e.g. hearing /kəʳ/ in ‘beaker’ can partially activate the phonologically similar rhyming word, ‘speaker’). Such partial activation is reflected in eye-movements while comprehenders listen to spoken instructions. In one study by Allopenna et al. (1998), participants were presented with line drawings of several objects on a computer screen before they were instructed to move one of the objects (via the computer’s mouse) to another location in relation to fixed geometric shapes in the display. Each display contained four geometric shapes, and four line drawn objects in a 5 × 5 grid. Of the four line drawn objects, one object was the target (e.g. ‘beaker’); another, a cohort competitor (e.g. ‘beetle’); another, a rhyme competitor (e.g. ‘speaker’); and finally, an unrelated control (e.g. ‘carriage’). Participants were more likely to fixate on the referent and cohort competitor than rhyme and control objects 200ms after the onset of the critical noun. Fixations on the target diverged from the cohort at 400ms. However, 300ms after the onset of the critical noun, participants were more likely to fixate on the rhyme competitor. Although fixations on the cohort competitor began earlier and peaked higher than the rhyme competitor, and fixations on the rhyme competitor continued for longer than the baseline. Such patterns were in-keeping with TRACE (McClelland & Elman, 1986) simulations, suggesting that fixations on each location were tied to lexical activation. Thus, several phonological candidates can compete with one-another when identifying a word.

Yee and Sedivy (2006) highlight that while many models of spoken word recognition agree that cohorts become partially active on mention (e.g. Luce & Pisoni, 1998; Marslen-Wilson & Welsh, 1978; McClelland & Elman, 1986), few models directly address access to meaning. Still, most models assume that when the form of a word is accessed, so is its meaning. This suggests that the meaning of various candidates is at least partially activated prior to settling on the correctly identified word. Such an assumption was borne out in eye-movement data during a passive listening task in one experiment by Huettig and Altmann (2005). In this study, participants took part in a ‘look and listen’ task under three viewing conditions. In all conditions, participants heard sentences such as, ‘Eventually, the man agreed hesitantly, but then he looked at the piano and appreciated that it was beautiful’. In one condition, the display contained the target (e.g. piano) and three semantically unrelated images (e.g. goat, hammer, carrot). In another condition, the display contained a semantically-related competitor (e.g. trumpet) and the same three semantically unrelated images. In a final condition, the display contained the target (e.g. piano) and semantically related competitor (e.g. trumpet) along with two semantically-unrelated competitors (e.g. goat, hammer). Of most relevance to the current study is this final condition, in which it was found that during mention of the target (piano) more saccades were directed towards the target than the competitor, but also more saccades were directed towards the competitor than the two distractors. This evidence was taken to suggest that when attempting to identify a word, semantic information about potential candidates is accessed.

Semantic competition during language processing has also been shown by Yee and Sedivy (2006). In one experiment, Yee and Sedivy seated participants in front of a touch sensitive screen containing four objects in each corner of a 3 × 3 array. Of these four objects, two were semantically related but phonologically unrelated (e.g. lock and key), and two were semantically and phonologically unrelated (e.g. deer and apple), an example of which is displayed in Figure 5.2.

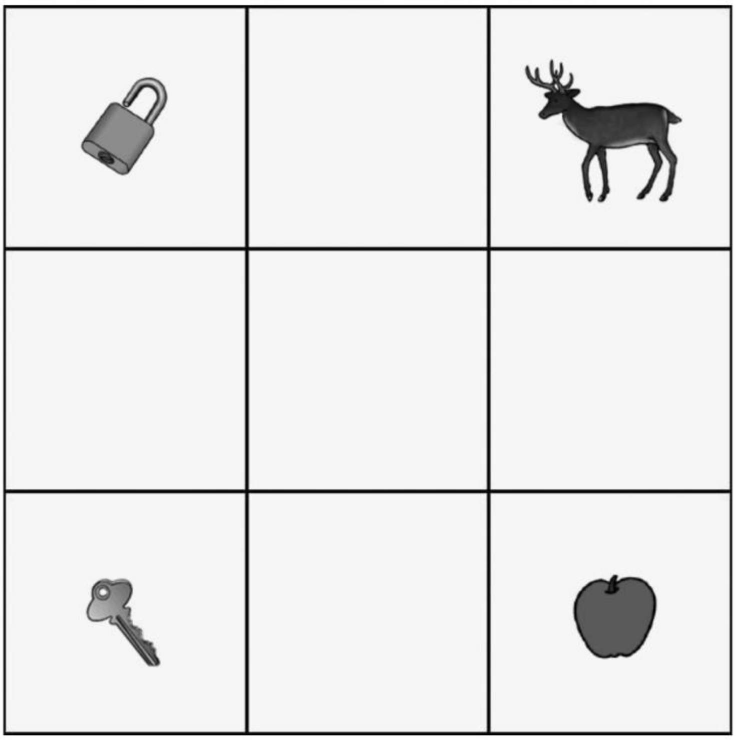


Figure 5.2. Example visual display used in Yee & Sedivy (2006)

In this experiment by Yee and Sedivy (2006), participants were instructed to press a red square in the centre of the display when it appeared, after which the red square disappeared while the name of one of the objects was played over speakers. Participants were then tasked with pressing one of the objects in the array. Two-hundred milliseconds after the onset of the critical noun (e.g. ‘lock’) until 900ms after the target onset there was a greater proportion of fixations on the semantic competitor than on the control object (e.g. apple). Moreover, the competitor received a larger proportion of fixations when the target was mentioned, and not when another control object (e.g. deer) was mentioned under similar visual contexts. Over time, Yee and Sedivy found that in separate analyses starting from 200ms, the target and competitor received a larger proportion of fixations than the distractor, and this effect persisted throughout the entire time-window (i.e. until 900ms after the onset of the critical noun). The growth in the proportion of fixations on the competitor peaked at around 200-300ms after target onset and remained above the proportion of fixations on competitors throughout. Here, the same pictures received a larger proportion of fixations when semantically-related to the target, but not when the target was unrelated to the competitor, indicating that conditional differences were not a fabrication of differences in the visual saliency of the objects. Moreover, when two objects were related to one-another but not the target, these objects did not receive a larger proportion of fixations than the unrelated target, and all objects in the display received a similar proportion of fixations prior to mention for the target, indicating that semantic competition only occurs on access for the target. Crucially, regardless of whether the items in the experiment were comprised of only those that were unassociated with one-another, or included those that lexically co-occur, a similar pattern of results was found. Moreover, this pattern of results was found for a number of items that varied along a range of semantic features, including items that share a similar function (e.g. tape and glue), items that interact (e.g. lock and key), and items that share other semantic relations (e.g. grapes and wine). A further experiment by Yee and Sedivy used a similar paradigm to the first, but replaced the target with a phonological onset competitor – such that lock bacame logs – while all other objects remained the same. Here, the same pattern of results as the first experiment was found; participants were more likely to fixate the phonological onset competitor than the control object, and the competitor received a larger proprotion of fixations when presented along with the target rather than a control object. Thus, semantic processing goes beyond the limits of those objects represented within the display.

A further visual world study by Yee, Overton, and Thompson-Schill (2009) manipulated the degree to which objects were semantically or associatively related to one another. In this experiment, four conditions set up cases in which two objects could be associatively but not semantically related to one another (e.g. iceberg-lettuce) (i.e. in the forward direction), associatively and semantically unrelated to one another (e.g. lettuce-iceberg) (i.e. in the backward direction), associatively and semantically related to one another (e.g. ham-eggs) (i.e. in the forward direction), or semantically but not associatively related to one another (e.g. eggs-ham) (i.e. in the backward direction). In this experiment, participants viewed an array containing two of these objects mentioned above, and two associatively, semantically, and phonologically unrelated objects. On hearing the name of the one of the object pairs, participants were tasked with using the computer mouse to click on one of the four objects in the array. Here, it was found that semantically related objects received a larger proportion of fixations regardless of whether they were associatively related to one another (e.g. ham-eggs) or not (e.g. eggs-ham). However, objects that were associatively but not semantically related to one another (e.g. iceberg-lettuce, lettuce-iceberg) did not attract a larger proportion of fixations than the distractors. These findings suggest that lexical co-occurrence is a poor measure by which to observe competition amongst objects during referential processing. While this is seemingly at odds with research by Huettig et al. (2006) showing that LSA (Landauer & Dumais, 1997) correlates well with fixation behaviour in eye-tracking tasks, Yee et al. (2009) note that LSA, a theory and method for computing the similarity between texts (based upon a large corpus) (see Section 5.1.2.3 for details), captures more than simple co-occurrence and, while perhaps weaker at capturing ‘pure’ semantic relatedness than, say, contextual similarity, it is likely that LSA is a valid method for generating a set of items that vary by semantic relatedness.

The series of experiments by Yee and Sedivy (2006) and Yee, Overton, and Thompson-Schill (2009) are important to consider for the present experiment as they show that (a) sematic competition occurs during lexical access relatively early on (200-300ms after the target), but decreases as time goes on, suggesting that there is a mechanism by which (semantically) competitive information is deactivated shortly after the target is identified; (b) competition between semantically related objects occurs regardless of whether this association includes a high degree of co-occurrence or not; and (c) competition can occur between items that share a phonological onset competitor. The implications for the present experiment are that semantic competition could serve as a means to address the advantage (in terms of accessibility) for information maintained in the foreground if it is susceptible to deactivation over time. Indeed, as semantic competition seems to be relatively long-lasting, peaking at around 300ms before trailing off at around 900ms after the onset of the critical noun, if foregrounding can influence accessibility for competitive sources of information the window in which this could occur is relatively large. On a different note, while competition occurs between items that are semantically related to one another but not between items that are only associatively related to one another, because items that are smeantically related are often also associatively related (Yee et al., 2009), and because LSA (Landauer & Dumais, 1997) captures more than simple co-occurrence, it is possible to use LSA to conveniently devise a range of items that are systematically controlled to account for the semantic relatedness amongst all items. In fact, as the present experiment is designed more to test whether event model structure can influence accessibility for competitive sources of information with little interest in the source of this competition beyond the target and competitor being different objects to one another, and is not concerned directly with ‘pure’ semantic competition, LSA provides an appropriate means for the generation of stimuli. As for the third point, this provides a restriction for which items can be included in the experiment, avoiding use of objects that are phonologically similar so that competition only occurs along one dimension.

One final consideration in the design of items for the present experiment is visual similarity. Dahan and Tanenhaus (2005) explored where participants look on hearing the name of a target (e.g. ‘snake’) when a display contained a line drawing of the target (e.g. snake), a visual competitor (e.g. rope) which shared some features with the target (i.e. the coiled and elongated shape associated with the snake), and two unrelated objects (e.g. umbrella and couch). Participants were instructed to use the computer mouse to click on the image of the target on mention, which could be 300ms or 1000ms after the display appeared on-screen. Crucially, while the target and competitor shared some similar visual features, these features were tied to the concepts of the percepts; where the target was a snake, the competitor – the rope – shared a coiled feature, but both were visually distinct in the display to ensure for ease of identification. Moreover, the target and competitor were phonologically unique. During a window between 200ms and 800ms after the onset of the critical noun, Dahan and Tanenhaus found a larger proportion of fixations on the competitor than either distractor. These results were built upon by Huettig and Altmann (2007) across two experiments exploring how context can manipulate the degree of competition derived from concepts that share similar visual features. In one experiment, the proportion of fixations on a target (e.g. snake) within a display was compared across conditions where a sentence prior to the onset of the critical noun either set up (a) a context related to the target (e.g. 'In the beginning, the zookeeper worried greatly, but then he looked at the snake…') or, (b) not (e.g. 'In the beginning, the man watched closely, but then he looked at the snake…'). A third condition, (c) replaced the image of the target in the display with a visual competitor (e.g. electric cable) in the target-biasing context (e.g. with sentences containing 'zookeeper' rather than 'man'). Huettig and Altmann found no differences in the proportion of fixations on any object in the neutral condition, (b), at the onset of the critical noun, however at the offset of the critical noun the target received a larger proportion of fixations than the distractors. In the context condition, (a), the target received a larger proportion of fixations than the distractors prior to the onset of the critical noun – with this effect persisting until the offset of the critical noun. In the competitor condition, (c), there was no difference in the proportion of fixations on the competitor and distractors either prior to or at the onset of the critical noun. However, at the offset of the critical noun, the competitor received a larger proportion of fixations than the distractors. Such results were interpreted as support that visual-shape information is accessed, and guides visual attention, even in the absence of a complete match to the target, such that items that best match the concept to be accessed will attract attention. Moreover, the proportion of fixations on the competitor was positively correlated to the degree of visual similarity between the target and competitor. However, context was found to play little role in guiding attention towards a visual competitor. Thus, in the present experiment, each object name was phonologically distinct (see Allopenna et al., 1998), avoiding use of object names that are cohort or rhyme competitors, and the targets and competitors will be visually distinct (see Dahan & Tanenhaus, 2005; Huettig & Altmann, 2007). Moreover, only the target and competitor were highly related to one-another in terms of LSA scores, with other interactions between objects (e.g. target-competitor, competitor-distractor) requiring a low score for semantic similarity.

The consistent finding across experiments addressing semantic competition (Huettig & Altmann, 2005; Yee & Sedivy, 2006) and visual competition (Dahan & Tanenhaus, 2005; Huettig & Altmann, 2007) is the idea that featural overlap between a target and competitor causes competition on access for the target (see Altmann & Kamide, 2007);

the more similar two objects are, the more likely they are to compete for visual attention on mention of the target. Under such assumptions, it is possible that sharing the same event model could act as another feature with which to increase the similarity amongst a target and competitor, and conversely, maintaining a target and competitor in separate event models could serve to reduce the overlap between a target and competitor. While both semantic and visual competition provide good candidates to address whether event structure can modulate the degree of competition exhibited between a target and competitor, semantic competition is most appropriate due to the convenient means by which the similarity between two objects can be addressed (e.g. LSA: Landauer & Dumais, 1997). Furthermore, unlike cohort competitors, that are initially ambiguous as to the name of the target, and rhyme competitors, which may cause confusion in identifying the target, semantic competitors can be relatively unambiguous as to which object they refer to in a visual array. This feature is crucial in ensuring easy identification for the target such that the event model containing the target becomes foregrounded on mention. With a range of evidence showing strong effects of semantic competition during discourse processing (Huettig & Altmann, 2005; Huettig & McQueen, 2007; Yee & Sedivy, 2006), it is likely that if event structure can influence the degree of competition between a target and competitor in terms of featural overlap, then this should be exhibited in semantic competition. As Yee and Sedivy (2006) note, it would be computationally demanding and simply confusing for a listener if all items semantically-related to a target were accessed on mention, and that context must act to reduce the number of potential candidates that become activated on mention for a target. Here, then, the present experiment explores whether context in the form of the event model structure can influence the amount of activation for a competitor (in terms of fixations on the semantic competitor) during discourse processing.

The present experiment aims to address whether maintaining a competitor in a separate event model to a target can act to reduce accessibility for the competitor, and hence increase accessibility for the target on mention for the target, thus aiming to observe positive effects of event model structure on accessibility for a target. In doing so, this experiment will also assess whether information in the working event model is more highly accessible than information outside of the working event model; addressing whether foregrounding effects persist without the need of a spatial shift made by a protagonist. In order to achieve this aim, the present experiment will present participants with a quadrant containing four objects (e.g. lock, key, ball, and melon) (see

Figure 5.1), two of which – the target and competitor (e.g. lock and key) – are semantically-related to one another, while they listen to sentences describing the target and competitor as being located Together, in the same location, or Apart, in separate locations (see Example 5.1). On hearing a final sentence that re-mentions the target, the proportion of fixations on each object will be analysed to establish whether semantic competition occurs, and whether describing the target and competitor in separate locations can reduce the amount of semantic competition found. Here, competition will be assessed by whether the competitor receives a larger proportion of fixations than the average of the two distractors on mention of the target. To address whether the two conditions can influence the amount of competition exhibited, the proportion of fixations on the target and competitor will be compared across the two conditions. In both conditions it is assumed that describing two locations will establish the creation of two event models in which the described objects will be maintained. In both cases, it is predicted that only the event model containing the target will be accessed on mention of the target. As such, in the Together condition, the event model containing the target (and all other objects within it) will become more accessible, resulting in competition in this case. Conversely, in the Apart condition it is predicted that only the event model containing the target will be accessed. Because the competitor is maintained in a separate event model, it should be less accessible on mention of the target. As such, less competition should occur in this case when compared to the condition in which the target and competitor were described as being in the same location.

5.1.2. Method

5.1.2.1. Participants

Sixty (11 male) native speakers of English from the University of Dundee community (aged 18-29, *M* = 20.62, *SD*= 3.66) took part in this study for partial course credit. All participants had uncorrected vision, wore soft contact lenses, or wore spectacles, and had no known auditory, visual, or language disorders.

5.1.2.2. Apparatus

The same apparatus used in Experiment 3 was used here. Nine-point calibration and validation was used at the start of the experiment and was repeated every 16th item.

5.1.2.3. Materials

The target (lock) appeared in each location of the visual scene (top left/right, bottom left/right) an equal number of times across items. Four pseudo-randomisation Latin squares were created for each of the locations of the target and the other objects (competitor, distractor 1, and distractor 2) relative to the target, resulting in 24 unique permutations of the four objects and their locations. The experimental items rotated across each permutation within each set before selecting two permutations within each set randomly, resulting in 8 repeated permutations for the layout of the quadrants for the experimental items. Thirty-two filler items were also included, using similar visual scenes and sentential structures to that of the experimental items; however, sentence 3 re-mentioned one of the two distractor objects (i.e. those not semantically-related to anything else in the visual scene or sentences). The same method used for pseudo-randomising the quadrants in the experimental items was used for the filler items, such that the 24 unique permutations were rotated across the 32 filler items, using each permutation once before selecting 8 further repeated permutations at random excluding those repeated for the experimental items. Four practice items were used at the beginning on the experiment, using two experimental-type items and two filler-type items. For the practice items, one of each of the permutations within the four sets was selected at random excluding those repeated in the experimental and filler-type items. As such, each unique permutation for the layout of the quadrant was repeated 3 times, excluding those of 4 items (items 3, 8, 15, and 23), which were only repeated twice.

All visual scenes contained visually-distinct targets and competitors, and all objects were inanimate objects that could be physically contained within the mentioned locations. All object names were singular and one word in length, with no rhymes or cohorts. Four fixed-random lists were created for the stimuli. Each list contained one version of the four sentence groups for each item in order to rotate across the sentential conditions while controlling for the order of mention. The order of presentation for items was randomised for each participant, with a maximum run length of 2 for condition such that only two items from the same condition could be played sequentially before another item from another condition followed. For a full list of the sentential stimuli used for recorded sentences, see Appendix F.1. For examples of all visual scenes, see Appendix F.2.

In order to obtain pairs of highly semantically-related objects to represent the targets and competitors in the present experiment, the example target-competitor pair (lock, key) from Yee and Sedivy (2006) was used as a baseline to develop further target-competitor pairs of similar semantic relatedness. LSA, a theory and method for computing the similarity between texts (based upon a large corpus) as a function of the relationship between their vectors in high-dimensional ‘semantic space’, was used to determine the semantic relatedness between the example target-competitor pair, and to obtain further target-competitor pairs. Notably, LSA can accurately simulate semantic priming data; with LSA similarity scores corresponding closely to those obtained in the real world (Landauer & Dumais, 1997). As such, LSA was determined to provide a convenient, accurate, and systematic method for determining target-competitor pairs in the present experiment. Using LSA, with restrictions of General Reading (up to first year college: 300 factors)[2], the example target-competitor pair (lock, key) was found to have an LSA cosine of .43 when using a pairwise comparison[3], and the distractor object pair (deer, apple) were found to have an LSA cosine of .10. However, when computing a term-to-term matrix comparison between all 4 objects (using General Reading (up to 1st year college: 300 factors)), it was found that the lock and key were highly related to the apple, with LSA cosines of .23 and .32 respectively. Thus, to ensure that only the target and competitor were highly related, new items were created under the criteria that the target and competitor pairs must share an LSA cosine of .40 or above, and all other interactions, i.e. between the target/competitor and both distractors, and between the

[2] The General Reading space (up to 1st year college) was determined to be most appropriate for a primarily Undergraduate cohort of participants. While dimensionality-optimisation is useful in determining the most appropriate number of factors to include in the representational space, using 300 factors has typically been found to be effective in accurately simulating human-like responses to various language-based tasks (Landauer & Dumais, 1997). Without the means to compare LSA cosines to human judgments for the semantic similarity between the objects used in the current experiment, 300 factors were used in the representational space.

[3] A similar term is returned when using the Matrix comparison – the method used in comparing target-competitor pairs with the two distractor objects.

two distractors, must share an LSA cosine of .10 or below. Moreover, because the present experiment used only inanimate objects, several items used in that of Yee and Sedivy were deemed inappropriate for selection. As such, while some items in the present experiment are similar to those used in Yee and Sedivy, only those items that adhered to the above restrictions were used, necessitating the generation of a large range of new stimuli. The average LSA cosines for every interaction in the matrix comparison between the final target, competitor, and two distractor objects across experimental, filler, and practice items in the present experiment are displayed in Table 5.1.

Table 5.1. LSA cosines for the comparisons between the target, competitor, and two distractor objects across items (N=68) in Experiment 7

	Competitor	Distractor 1	Distractor 2
Target	0.59	0.03	0.03
Competitor	—	0.01	0.02
Distractor 1	—	—	0.03

As can be seen from Table 5.1, while overall the target and competitor are highly related to one-another, all other relations between the objects mentioned in each sentence are very low. This suggests that in the set of items used for Experiment 7, only the target and competitor are semantically related. In order to ensure that any semantic competition effects were driven by semantic similarity between the target and competitor and not by differences in the semantic association between the target and competitor in regards to the two locations, a one-to-many comparison, using General Reading (up to 1st year college: 300 factors) as a semantic space, was carried out for the target and competitor items in regards to the two mentioned locations. The average LSA cosines for the relatedness of the target and competitor in regards to the two locations are displayed in Table 5.2.

Table 5.2. LSA cosines for the relatedness of the target and competitor in regards to the two locations (N=68) in Experiment 7

	Target	Competitor
Location 1	0.10	0.10
Location 2	0.11	0.10

Observing Table 5.2, it is apparent that the relatedness of the target and competitor to the two locations is equivalent across items. Thus, any effect of semantic relatedness found in Experiment 7 is unlikely to be affected by differences in the semantic relatedness between the target and competitor in regards to the two mentioned locations.

Therefore, fixations on the competitor when hearing the target noun are likely to be driven by competition between the target and competitor directly, and not by activating the location associated with the target with spreading activation for the competitor if this object is highly associated with said location. Together, the two comparisons carried out here have confirmed that the items used in Experiment 7 are fit for use in a semantic competition task.

5.1.2.4. Procedure

Participants were instructed to look at visual scenes as they appear on the screen and to listen to spoken narratives played over speakers. A look and listen task was selected to avoid any unnatural processing strategies during the task (Altmann, 2004). Each visual scene remained on-screen for the duration of the trial (average of 16,090ms) so that the visual scenes and auditory stimuli were presented concurrently. Participants completed four practice trials at the beginning of the experiment, after which they had the opportunity to ask any questions prior to the continuation of testing. The practice trials consisted of two experimental-type items and two filler-type items. The experimental session consisted of 32 experimental and 32 filler items as outlined in Section 5.1.2.3. For all trials, each scene was displayed for a preview of 1000ms and remained on-screen for the duration of the trial); sentences 1 and 2 were played after this preview. 1000ms after the offset of the second sentence, the third (critical) sentence was played. Each individual trial was automatically terminated 4000ms after the offset of the final sentence. The average durations, onsets, and offsets for each region are presented in Table 5.3. The full testing session lasted approximately 30 minutes.

5.1.3. Results

Data were prepared and analysed using R version 3.2.2 (R Development Core Team, 2008), using the `lme4` package (version 1.1-9). A similar method of analysis used in Experiment 1 was used here, with the data down-sampled from a 1000Hz temporal resolution so that fixations were reported every 10ms, aggregated across 50ms time bins. However, in this experiment two sets of analyses were carried out in order to first address the extent of any semantic competition effects in each condition (Apart, Together) before directly assessing whether the two conditions influenced the proportion of (transformed) fixations on the target (lock), competitor (key), and average of the two distractors (ball, melon) (henceforth 'distractor'). In order to carry out these comparisons, the first set of analyses split the data by condition, comparing the (transformed) proportion of fixations on the target (lock), competitor (key), and the distractor (ball, melon) in the Apart condition, before carrying out the same analysis for the Together condition. These sets of analyses were carried out specifically to check that, on mention of the target, the target was fixated on more often than the competitor. However, this analysis was also used to explore whether the competitor was fixated on more often than the two distractors (specifically, the average of the two distractors) during this region, providing a test for any semantic competition within the two conditions. In both cases separate by-items and by-participants analyses were carried out.

The second set of analyses directly compared the (transformed) proportion of fixations on the target (lock) across the two conditions, before repeating the same process for the competitor (key), and the distractor (ball, melon). These sets of analyses were carried out specifically to test the magnitude of any difference in the proportion of fixations on the target, competitor, and the average of the two distractors as a measure of any difference in the accessibility for these objects across conditions. In doing so, these analyses provide a measure of the extent to which any semantic competition – highlighted in the first set of analyses – is influenced by condition (i.e. whether the target and competitor are together or apart from one another), showing whether any increase in the transformed proportion of fixations on the competitor is associated with a decrease in the transformed proportion of fixations on the target, and not on the average of the two distractors. Again, in both cases separate by-items and by-participants analyses were carried out. In all analyses, the average proportion of fixations on the two distractors was calculated by taking the mean proportion of fixations on both regions before transforming the data (i.e. computing the empirical logit). To control for the recency of mention of the target and competitor, the four manipulations of sentence group 1 in Example 5.1 were collapsed such that the Apart (1-2c, d) and Together (1-2a, b) conditions reflected cases in which the target and competitor were mentioned in the first and second sentences, and thus in the first-mentioned and second-mentioned locations, within items. In all analyses, the region of analysis was determined on a trial-by-trial basis (see Table 5.3 for mean durations).

Following Barr (2008), the onset of the region of analysis was determined at the earliest point at which eye movements to the target were driven by the linguistic stimuli. As in previous experiments in this thesis, this was estimated to be 200ms after the onset of the critical noun (‘lock’) to account for the time taken to launch a saccade (Matin et al., 1993). Here, as in previous experiments in this thesis that have shifted the onset of the time-window, the offset of the time-window is extended by the same amount in which the onset of the time-window was restricted; extending the time-window to 200ms after word offset in this case. The mean duration of fixations was calculated for each time window, with the transformed proportion of fixations on each interest area calculated starting from the onset of the first saccade on each given interest area at the beginning of the region of analysis until the offset of the critical region within each (hand drawn) region of interest. Table 5.3 shows the average onset, offset, and duration for each region, taking into account variability with onsets as a result of the experimental program.

Table 5.3. Mean durations of temporal regions in the experimental sentences (ms) in Experiment 7

Label	Region	Onset	Offset	Duration
Sentences 1 and 2				
	‘The lock and the key are in the cafeteria. The ball and the melon are in the parlour.’	1060	7835	6775
Sentence 3				
verb phrase	‘It seems that’	8835	9825	990
determiner	‘the’	9825	9965	140
object noun	‘lock’ (target)	9965	10,425	460
verb	‘is’	10,425	10,820	395
adverb	‘very’	10,820	11,605	785
adjective	‘old’	11,605	12,090	485

Note: Sentences 1 and 2 varied across conditions. The region example provided above is based on one of the four conditions outlined in Example 5.1, 1-2a.

The average proportion of transformed fixations on each interest area is reported first, comparing each interest area to one another. This is reported for the Together condition prior to the Apart condition, after which the transformed proportion of fixations on each area are reported individually, comparing each condition to one another.

5.1.3.1. Analyses 200ms after the onset until 200ms after the offset of the critical noun ('lock')

5.1.3.1.1. Looks on the target (lock), competitor (key), and distractor (ball, melon) in the Together condition

Analyses of the transformed proportion of fixations on the target (lock), competitor (key) and two distractors (ball, melon) were carried out on the region 200ms after the onset until 200ms after the offset of the critical noun ('lock') in sentence 3 in the Together condition. The average proportion of fixations on these regions in the Together condition is shown in Figure 5.3.

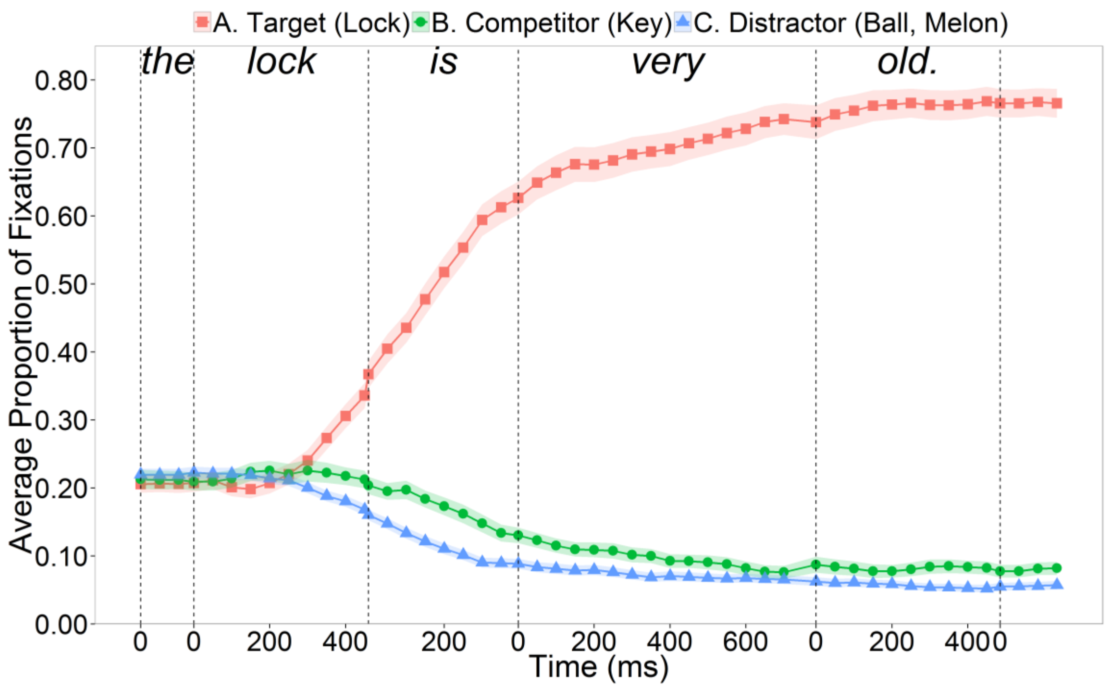


Figure 5.3. Average proportion of fixations on the target (lock), skateboard (key), and distractor (ball, melon) by participants (N=60) in the Together condition in Experiment 7; shaded bands show standard error

Table 5.4 shows the mean proportion of fixations and *SD* for the analysed region 200ms after the onset until 200ms after the offset of the critical noun ('lock'). The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

Table 5.4. Means and standard deviations for the proportion of fixations on the target (lock), competitor (key), and distractor (ball, melon) 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) in the Together condition in Experiment 7

Interest Area	*M*	*SD*
Target (lock)	0.321	0.170
Competitor (key)	0.212	0.108
Distractor (ball, melon)	0.173	0.070

Empirical logit analyses (Barr, 2008) were conducted to analyse the average fixations (log odds scale) on each interest area (target, competitor, average distractor) 200ms after the onset until 200ms after the offset of the critical noun (‘lock’). Two models were created and run separately for by-participants and by-items analyses respectively, exploring the main effect of interest area on fixations over time. Inspection of the observed transformed data in Figure 5.4 revealed a linear change in the transformed proportion of fixations on each interest area during the analysed time-window, hence time was modelled as a fixed factor using orthogonal linear polynomials (i.e. instead of higher-order polynomials; see Mirman et al., 2008).

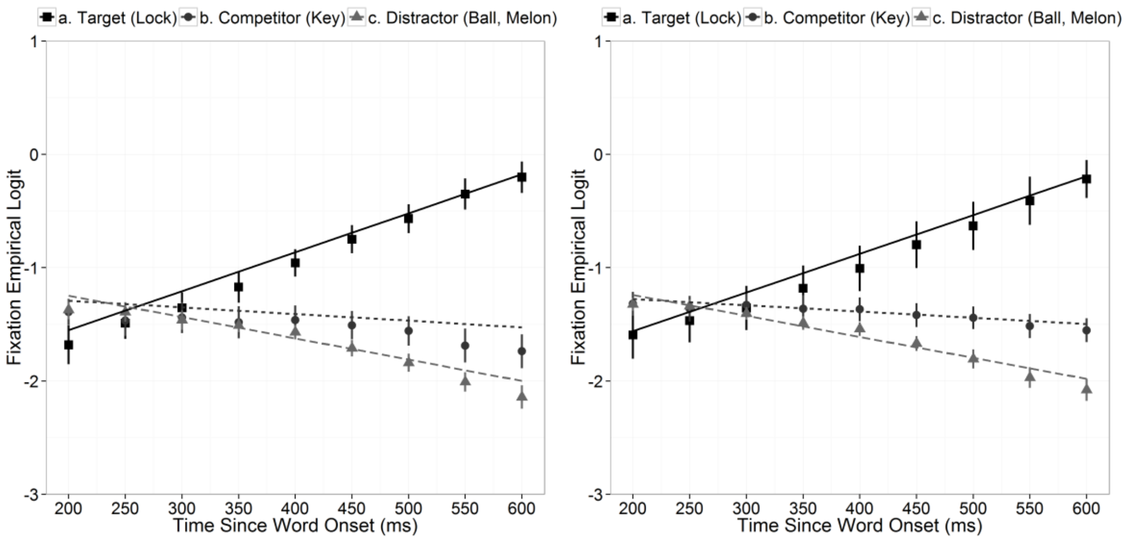


Figure 5.4. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=32) to the target (lock), competitor (key), and distractor (ball, melon) 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) in the Together condition in Experiment 7; point-ranges represent the empirical logit and their standard errors

In both by-participants and by-items models, dummy coding was used such that the target initially represented the baseline in each model. Both models used a maximal converging random effects structure (Barr et al., 2013), with random effects of participants and participants nested within interest area on the intercept and slope terms for the by-participants analysis, and with random effects of item and item nested within interest area on the intercept and slope terms for by-items analysis. Both models contained fixed effects of the orthogonal linear time term and interest area on the intercept and slope. For full model examples, see Appendix F.3. In order to obtain comparisons for the competitor and distractor, contrasts were performed using the `glht` function from the `multcomp` library (version 1.4-1), adjusting for multiple comparisons using the single-step method. For both models, statistical significance for individual parameter estimates was calculated using the normal approximation. For full model examples, see Appendix F.3. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 5.5.

Table 5.5. By-participants [1] (N=60) and by-items [2] (N=32) parameter estimates for the comparisons between the transformed fixations on the target (lock), competitor (key), and distractor (ball, melon) 200ms after the onset until 200ms after the offset of the critical noun ('lock') in the Together condition in Experiment 7

Contrast	β	*SE*	z-value	Pr(>|z|)
Target vs. Competitor [1]				
Intercept	-0.546	0.115	-4.744	<.001***
Linear	-1.559	0.140	-11.101	<.001***
Target vs. Competitor [2]				
Intercept	-0.510	0.143	-3.568	.002**
Linear	-1.537	0.139	-11.070	<.001***
Target vs. Distractor [1]				
Intercept	-0.760	0.115	-6.616	<.001***
Linear	-2.058	0.140	-14.672	<.001***
Target vs. Distractor [2]				
Intercept	-0.733	0.143	-5.131	<.001***
Linear	-2.041	0.139	-14.648	<.001***
Competitor vs. Distractor [1]				
Intercept	-0.214	0.115	-1.864	.275
Linear	-0.499	0.141	-3.541	.002**
Competitor vs. Distractor [2]				
Intercept	-0.224	0.143	-1.568	.451
Linear	-0.503	0.139	-3.616	.002**

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 5.5 shows a significant difference between the target and competitor on the intercept (p_1<.001; p_2=.002) and linear terms (p_1<.001; p_2<.001), reflecting a larger proportion of fixations on the target throughout the entire time-window and as time goes on, respectively, when compared to the competitor in the Together condition. Similar findings are reported for the comparison between the target and distractor on the intercept and linear terms (all ps<.001), indicating that the target receives a larger proportion of fixations throughout the entire time-window and as time goes on when compared to the distractor in the Together condition. For the comparison between the competitor and distractor, there is no significant difference between the proportion of fixations on the two objects on the intercept term (p_1=.275; p_2=.451), indicating that the proportion of fixations on both objects does not differ throughout the entire time-window in the Together condition. However, there is a significant difference in the proportion of fixations on the two objects on the linear term (p_1=.002; p_2=.002), indicating that as time goes on the competitor receives a larger proportion of fixations than the distractor in the Together condition.

5.1.3.1.2. Looks on the target (lock), competitor (key), and distractor (ball, melon) in the Apart condition

Similar analyses to those carried out for the transformed proportion of fixations on the target, competitor, and distractor in the Together condition were carried out here, for the Apart condition. The average proportion of fixations on these regions in the Apart condition is shown in Figure 5.5.

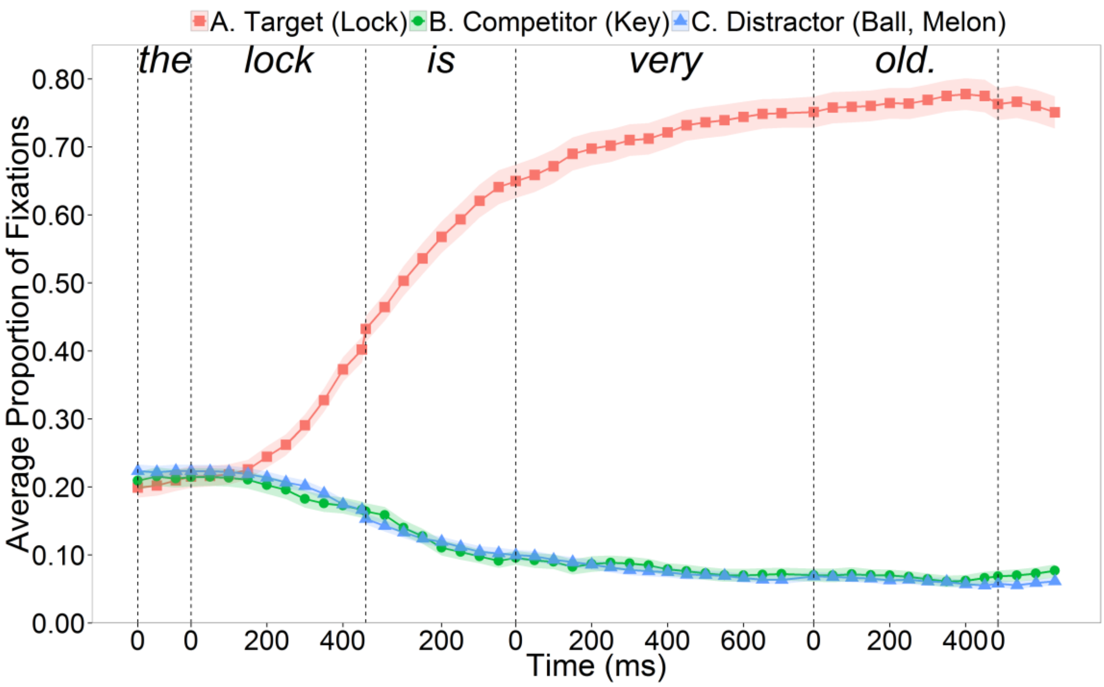


Figure 5.5. Average proportion of fixations on the target (lock), skateboard (key), and two distractors (ball, melon) by participants (N=60) in the Apart condition in Experiment 7; shaded bands show standard error

Table 5.6 shows the mean proportion of fixations and *SD* for the analysed region, 200ms after the onset until 200ms after the offset of the critical noun (‘lock’). The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

Table 5.6. Means and standard deviations for the proportion of fixations on the target (lock), competitor (key), and distractor (ball, melon) 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) in the Apart condition in Experiment 7

Interest Area	*M*	*SD*
Target (lock)	0.376	0.175
Competitor (key)	0.169	0.094
Distractor (ball, melon)	0.174	0.070

Inspection of the observed transformed data in Figure 5.6 revealed a linear change in the transformed proportion of fixations on each interest area during the analysed time-window, hence, similarly to the approach used in Section 5.1.3.1.1, time was modelled as a fixed factor using orthogonal linear polynomials (i.e. instead of higher-order polynomials; see Mirman et al., 2008).

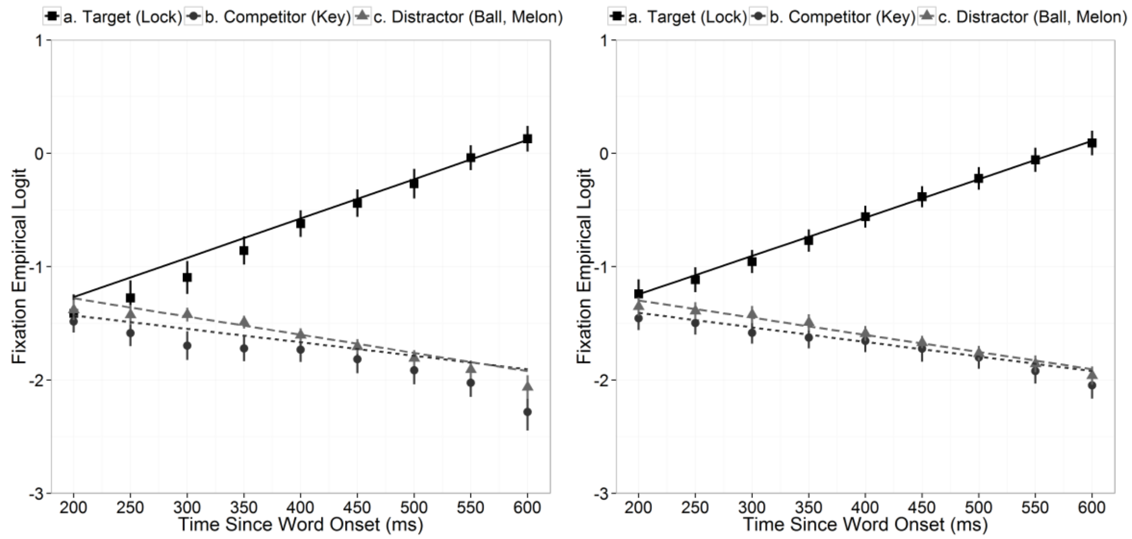


Figure 5.6. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=32) to the target (lock), competitor (key), and distractor (ball, melon) 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) in the Apart condition; point-ranges represent the empirical logit and their standard errors in Experiment 7

The same models and methods used to analyse the transformed proportion of fixations on each interest area in Section 5.1.3.1.1 were used here. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 5.7.

Table 5.7. By-participants [1] (N=60) and by-items [2] (N=32) parameter estimates for the comparisons between the transformed fixations on the target (lock), competitor (key), and distractor (ball, melon) 200ms after the onset until 200ms after the offset of the critical noun ('lock') in the Apart condition in Experiment 7

Contrast	*β*	*SE*	z-value	Pr(>|z|)
Target vs. Competitor [1]				
Intercept	-1.093	0.101	-10.784	<.001***
Linear	-1.804	0.140	-12.887	<.001***
Target vs. Competitor [2]				
Intercept	-1.099	0.110	-9.953	<.001***
Linear	-1.810	0.157	-11.523	<.001***
Target vs. Distractor [1]				
Intercept	-1.026	0.101	-10.141	<.001***
Linear	-1.964	0.139	-14.099	<.001***
Target vs. Distractor [2]				
Intercept	-1.035	0.110	-9.385	<.001***
Linear	-1.899	0.157	-12.113	<.001***
Competitor vs. Distractor [1]				
Intercept	0.067	0.101	0.660	.954
Linear	-0.161	0.141	-1.141	.737
Competitor vs. Distractor [2]				
Intercept	0.063	0.111	0.572	.973
Linear	-0.089	0.158	-0.563	.974

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 5.7 shows a significant difference between the target and competitor on the intercept and linear terms (all *p*s<.001), reflecting a larger proportion of fixations on the target object throughout the entire time-window and as time goes on, respectively, when compared to the competitor in the Apart condition. Similar findings are reported for the comparison between the target and distractor on the intercept and linear terms (all *p*s <.001), indicating that the target receives a larger proportion of fixations throughout the entire time-window and as time goes on when compared to the distractor in the Apart condition. For the comparison between the competitor and distractor, there is no significant difference between the proportion of fixations on the two objects on the intercept (p_1=.954; p_2=.973) or linear term (p_1=.737; p_2=.974). This indicates that there is no difference in the proportion of fixations on the competitor and distractor throughout the entire time-window and as time goes on in the Apart condition.

5.1.3.1.3. Comparing looks on the target (lock) in the Together vs. Apart conditions

Empirical logit analyses (Barr, 2008) were conducted to analyse the average fixations (log odds scale) on the target (lock) 200ms after the onset until 200ms after the offset of the critical noun ('lock') in sentence 3 across the Together and Apart conditions. The average proportion of fixations on the target across conditions is shown in Figure 5.7.

Here, the target receives a numerically larger proportion of fixations in the Apart condition (*M*=0.376, *SD*=0.175) when compared to the Together condition (*M*=0.321, *SD*=0.170).

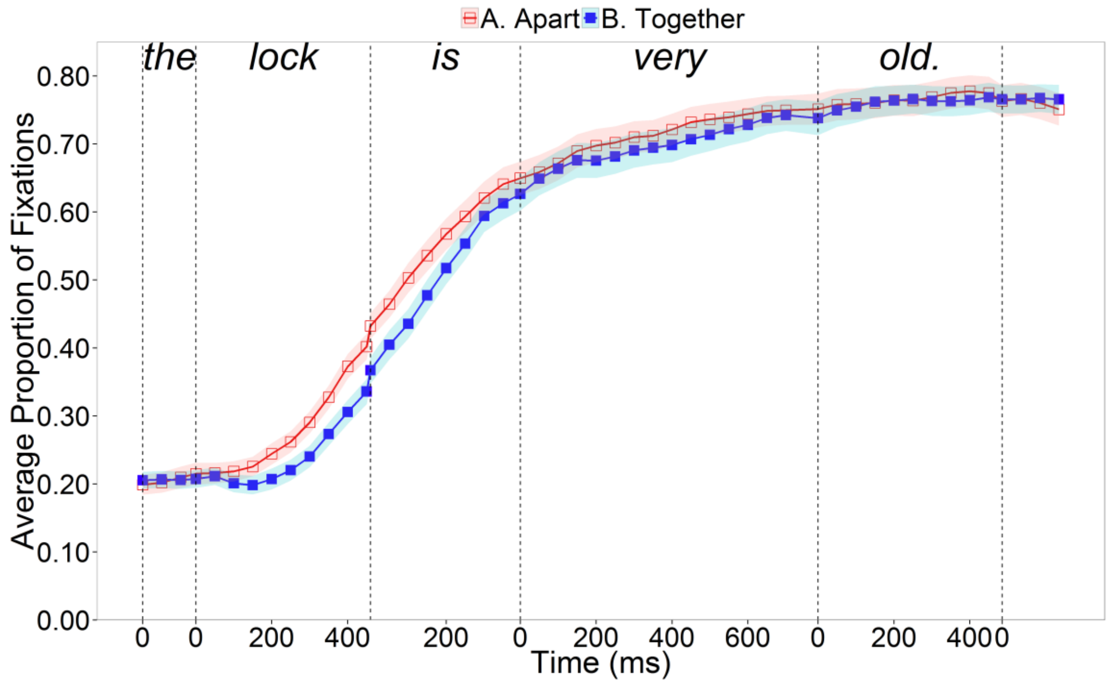


Figure 5.7. Average proportion of fixations on the target (lock) by participants (N=60) in the Apart and Together conditions in Experiment 7; shaded bands show standard error

Two models were created and run separately for by-participants and by-items analyses respectively, exploring the main effect of condition on fixations on the target (lock) over time. Inspection of the observed transformed data in Figure 5.8 revealed a linear change in the transformed proportion of fixations on the target (lock) during the analysed time-window, hence time was modelled as a fixed factor using orthogonal linear polynomials (i.e. instead of higher-order polynomials; see Mirman et al., 2008).

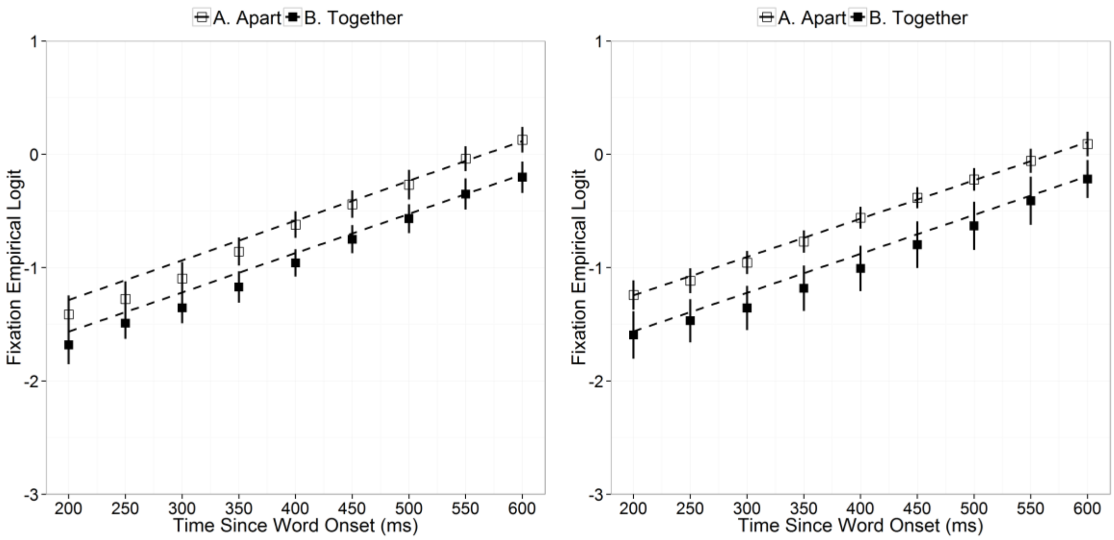


Figure 5.8. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=32) on the target (lock) in the Apart and Together conditions 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) in Experiment 7; point-ranges represent the empirical logit and their standard errors

In both by-participants and by-items models, dummy coding was used such that the Apart condition represented the baseline in each model. Both models used a maximal converging random effects structure (Barr et al., 2013), with random effects of participants and participants nested within condition on the intercept and linear terms for the by-participants analysis and with random effects of item and item nested within condition on the intercept and linear terms for by-items analysis. Both models contained fixed effects of the orthogonal linear time term and condition on the intercept and slope. For full model examples, see Appendix F.3. For both models, statistical significance for individual parameter estimates was calculated using the normal approximation. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 5.8. As in other analyses on experiments using only two levels within a factor, a reference level within a factor is used as the baseline condition for all analyses in this chapter focusing on the differences in conditions in the proportion of fixations on any one object. In this case, the Apart condition is used as the baseline for the Intercept and time-terms, such that the Intercept term represents the Apart condition’s intercept, and the linear (or higher) terms represent the Apart condition’s slope. The factor term – in this case the Together term – represents the Together condition’s intercept relative to the Apart condition’s intercept, and the time-terms crossed by factor (e.g. Linear: Together) represents the Together condition’s slope relative to the Apart condition’s slope; similar interpretations are applied when using higher-order time terms. Thus, the Together term must be consulted in order to make inferences about the effect of condition on the proportion of fixations throughout the entire time-window, and the Linear: Together term must be consulted in order to make inferences about the differences in the rate of access for an object across conditions.

Table 5.8. By-participants [1] (N=60) and by-items [2] (N=32) parameter estimates for the transformed fixations on the target (lock) 200ms after the onset until 200ms after the offset of the critical noun ('lock') in Experiment 7

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-0.584	0.095	-6.161	<.001***
Linear	-1.359	0.115	11.811	<.001***
Together	-0.287	0.090	-3.184	.001***
Linear: Together	-0.016	0.110	-0.143	.887
By-items [2]				
Intercept	-0.567	0.114	-4.967	<.001***
Linear	1.308	0.102	12.793	<.001***
Together	-0.310	0.094	-3.296	.001***
Linear: Together	0.020	0.120	0.167	.868

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 5.8 shows a significant difference between the Apart and Together conditions on the intercept term (p_1=.001; p_2=.001), showing a larger proportion of fixations on the target throughout the entire time-window in the Apart condition when compared to the Together condition. However, there is no significant difference between the two conditions on the linear term (p_1=.887; p_2=.868), indicating that as time goes on there in no change in the rate of increase in the proportion of fixations on the target across conditions.

5.1.3.1.4. Comparing looks on the competitor (key) in the Together vs. Apart conditions

Similar analyses to those carried out for the transformed proportion of fixations on the target (lock) across the two conditions were carried out here, for the competitor (key). Namely, empirical logit analyses were conducted to analyse the average fixations (log odds scale) on the competitor (key) 200ms after the onset until 200ms after the offset of the critical noun ('lock') in sentence 3 across the Apart and Together conditions. The average proportion of fixations on the competitor (key) across the two conditions is shown in Figure 5.9. Here, the competitor receives a numerically larger proportion of fixations in the Together condition (*M*=0.212, *SD*=0.108) when compared to the Apart condition (*M*=0.167, *SD*=0.094).

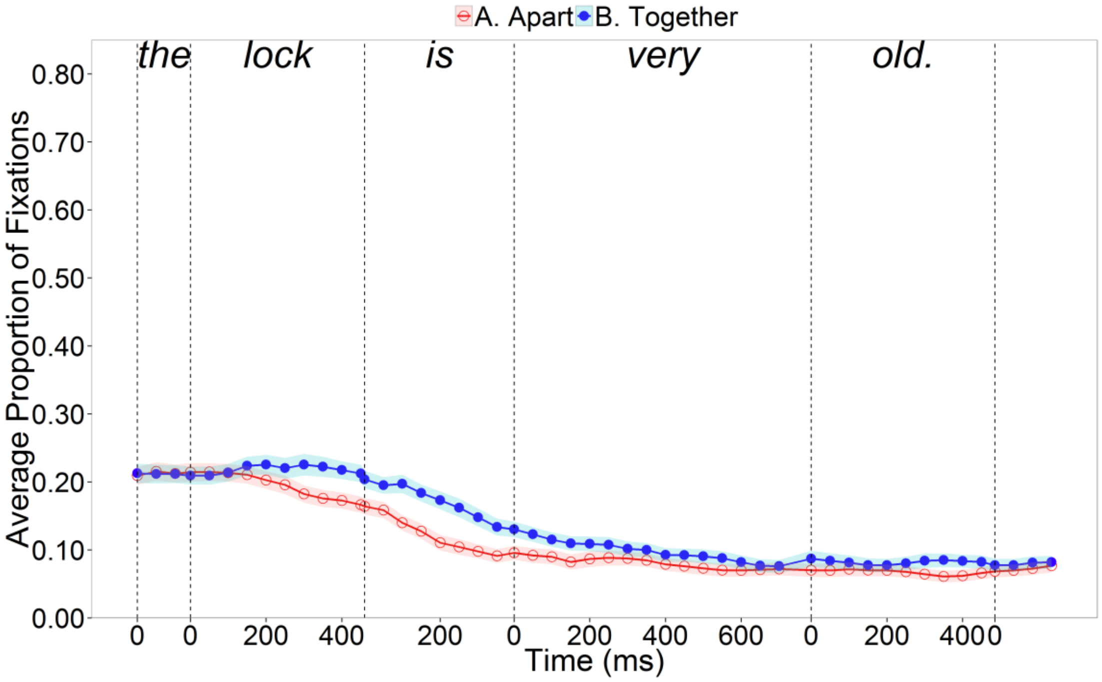


Figure 5.9. Average proportion of fixations on the competitor (key) by participants (N=60) in the Apart and Together conditions in Experiment 7; shaded bands show standard error

Two models were created and run separately for by-participants and by-items analyses respectively, exploring the main effect of condition on fixations over time. Inspection of the observed transformed data in Figure 5.10 revealed one point of inflection in the transformed proportion of fixations on the competitor (key) throughout the analysed time-window; as such second-order (quadratic) orthogonal polynomials were preferred over lower-order orthogonal polynomials in this analysis (e.g. Mirman et al., 2008).

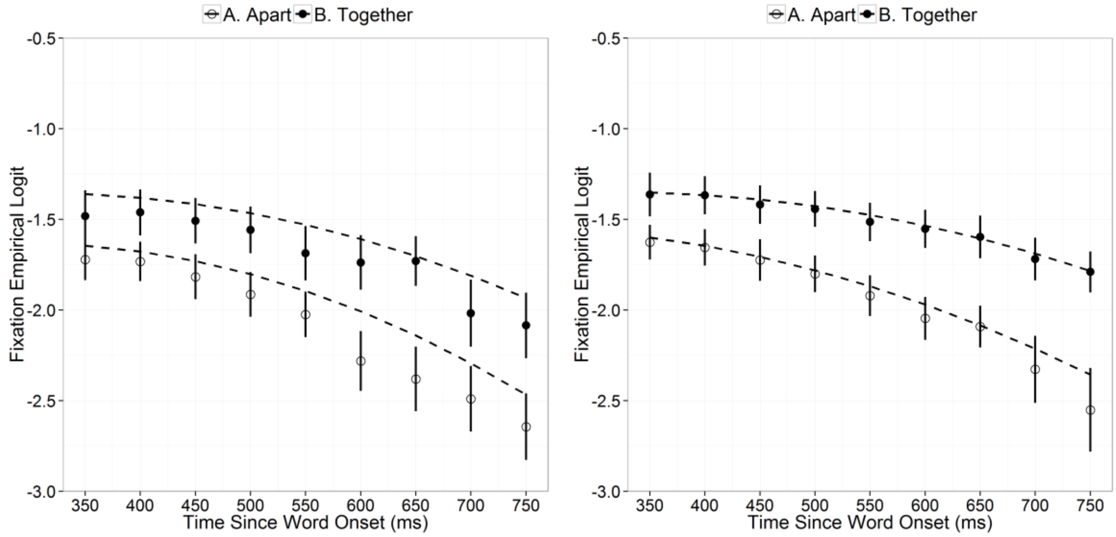


Figure 5.10. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=32) on the competitor (key) in the Apart and Together conditions 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) in Experiment 7; point-ranges represent the empirical logit and their standard errors

Similar models and methods used to analyse the transformed proportion of fixations on the target across conditions (see Section 5.1.3.1.3) were used in the analysis for the transformed proportion of fixations on the competitor (key) across conditions, with the only change here involving the inclusion of the higher-order (quadratic) time term. Both models contained fixed effects of the orthogonal linear and quadratic time terms and condition on the intercept and slopes. This model also used a maximal converging random effects structure (Barr et al., 2013), with random effects of participants and participants nested within condition on the intercept and slope terms for the by-participants analysis, and with random effects of item and item nested within condition on the intercept and slope terms for the by-items analysis. For full model examples, see Appendix F.3. For both models, statistical significance for individual parameter estimates was calculated using the normal approximation. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 5.9.

Table 5.9. By-participants [1] (N=60) and by-items [2] (N=32) parameter estimates for the transformed fixations on the competitor (key) 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) in Experiment 7

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-1.702	0.084	-20.233	<.001***
Linear	-0.516	0.108	-4.760	<.001***
Quadratic	-0.095	0.065	-1.457	.145
Together	0.267	0.116	2.301	.021*
Linear: Together	0.263	0.136	1.937	.053^{+}
Quadratic: Together	-0.040	0.085	-0.465	.642
By-items [2]				
Intercept	-1.677	0.087	-19.255	<.001***
Linear	-0.513	0.133	-3.855	<.001***
Quadratic	-0.109	0.060	-1.823	.068^{+}
Together	0.283	0.098	2.892	.004**
Linear: Together	0.298	0.171	1.747	.081^{+}
Quadratic: Together	0.029	0.082	0.355	.723

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 5.9 shows a significant difference between the Apart and Together conditions on the intercept term (p_1=.021; p_2=.004), showing a larger proportion of fixations on the competitor throughout the entire time-window in the Together condition when compared to the Apart condition. Moreover, there is a marginally significant difference between the two conditions on the linear term (p_1=.053; p_2=.081), showing that the rate of access for the competitor is faster in the Together condition when compared to the Apart condition (on the linear term).

5.1.3.1.5. Comparing looks on the distractor (ball, melon) in the Together vs. Apart conditions

Similar analyses to those carried out for the transformed proportion of fixations on the target (lock) across the two conditions were carried out here, for the distractor (ball, melon). Namely, empirical logit analyses were conducted to analyse the average fixations (log odds scale) on the distractor (ball, melon) 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) in sentence 3 across the Apart and Together conditions. The average proportion of fixations on the distractor (ball, melon) across the two conditions is shown in Figure 5.11. Here, the distractor receives a numerically larger proportion of fixations in the Apart condition (M=0.174, SD=0.070) when compared to the Together condition (M=0.173, SD=0.070).

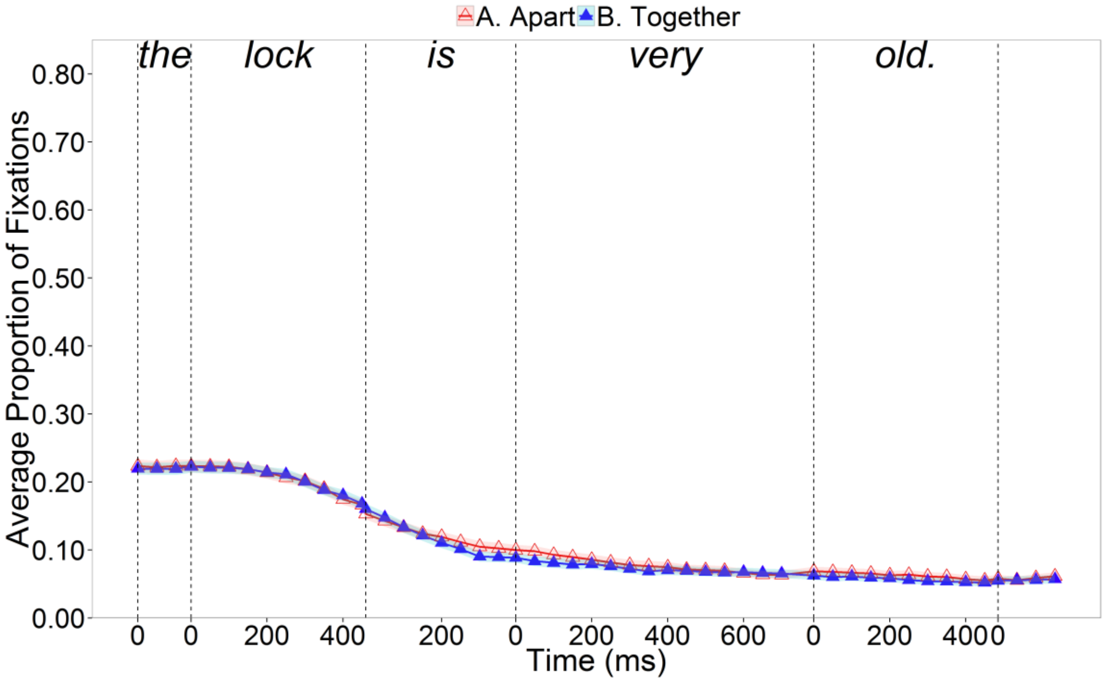


Figure 5.11. Average proportion of fixations on the distractor (ball, melon) by participants (N=60) in the Apart and Together conditions in Experiment 7; shaded bands show standard error

Two models were created and run separately for by-participants and by-items analyses respectively, exploring the main effect of condition on fixations over time. Inspection of the observed transformed data in Figure 5.12 revealed a linear change in the transformed proportion of fixations on the distractor (ball, melon) during the analysed time-window, hence time was modelled as a fixed factor using orthogonal linear polynomials (i.e. instead of higher-order polynomials; see Mirman et al., 2008).

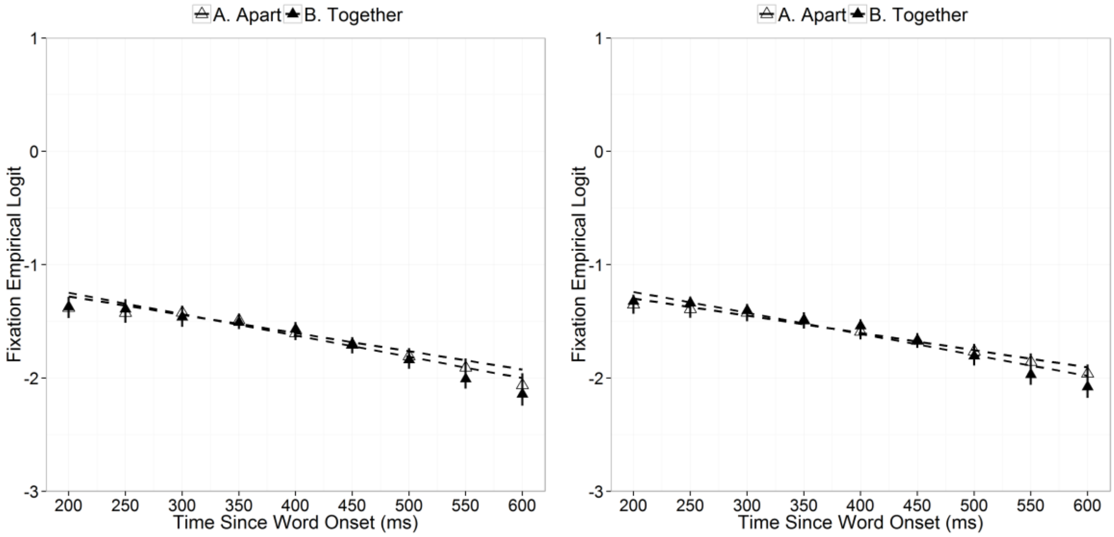


Figure 5.12. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=32) on the distractor (ball, melon) in the Apart and Together conditions 200ms after the onset until 200ms after the offset of the critical noun ('lock') in Experiment 7; point-ranges represent the empirical logit and their standard errors

The same models and methods used to analyse the transformed proportion of fixations on the target (lock) across conditions (see Section 5.1.3.1.3) were used in the analysis for the transformed proportion of fixations on the distractor (ball, melon) across conditions. For full model examples, see Appendix F.3. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 5.10.

Table 5.10. By-participants [1] (N=60) and by-items [2] (N=32) parameter estimates for the transformed fixations on the distractor (ball, melon) 200ms after the onset until 200ms after the offset of the critical noun ('lock') in Experiment 7

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-1.603	0.055	-29.190	<.001***
Linear	-0.624	0.081	-7.716	<.001***
Together	-0.022	0.063	-0.347	.728
Linear: Together	-0.105	0.094	-1.125	.261
By-items [2]				
Intercept	-1.602	0.062	-25.754	<.001***
Linear	-0.589	0.074	-7.935	<.001***
Together	-0.009	0.052	-0.172	.863
Linear: Together	-0.129	0.092	-1.403	.161

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 5.10 shows no significant difference between the Apart and Together conditions on both the intercept (p_1=.728; p_2=.863) and linear terms (p_1=.261; p_2=.161), indicating that there is no difference between the two conditions in the proportion of fixations on the distractor either throughout the entire time-window or as time goes on, respectively.

5.1.3.1.6. Summary of results for semantic competition 200ms after the onset until 200ms after the offset of the critical noun ('lock')

The analyses for the region 200ms after the onset until 200ms after the offset of the critical noun ('lock') showed that in both the Apart and Together conditions, the target received a larger proportion of fixations than the competitor and distractor both throughout the entire time-window and as time went on. In the Together condition, while there was no significant difference between the proportion of fixations on the competitor and distractor throughout the entire time-window, as time went on the competitor received a larger proportion of fixations than the distractor (on the linear term), indicating that as time goes on the competitor is more accessible than the distractor in the Together condition. This suggests that in the Together condition semantic competition occurs as time progresses. However, in the Apart condition, there was no difference between the competitor and distractor both throughout the entire time-window and as time went on, indicating that no semantic competition occurred in this condition. Throughout this same time-window the target received a larger proportion of fixations in the Apart condition when compared to the Together condition. However, there was no difference between the two conditions in the proportion of fixations on the target over time. The inverse pattern of results was true for the proportion of fixations on the competitor, with a larger proportion of fixations on the competitor throughout the entire time-window in the Together condition when compared to the Apart condition. Here, there was also a marginally significant difference between the two conditions on the linear term, suggesting that as time goes on the competitor is more accessible in the Together condition than the Apart condition. Finally, there was no difference between the two conditions in regards to the proportion of fixations on the distractor both throughout the entire time-window and as time went on.

Overall, the present findings suggest that while the competitor received a larger proportion of fixations when in the Together condition (vs. Apart condition) – presumably at a cost to fixations on the target, and not the distractor – this difference was only manifested as semantic competition as time went on in the analysed time-window. As such, it is clear that semantic competition only occurs (as time goes on) in the Together condition, and not in the Apart condition. Indeed, observing Figure 5.3, it is clear that this effect of semantic competition persisted during a spill-over region ('is') following the critical noun in the Together condition. Such an effect is unsurprising given that the semantic competition reported in Yee and Sedivy (2006) persisted until

900ms following the target onset. Moreover, Yee and Sedivy reported a general increase in fixations on the competitor around 200-300ms following the target onset, after which the competitor received a steadily larger proportion of fixations than the distractor. This is in-keeping with prior research that suggests that semantic competition effects typically begin around 300-400ms after target onset in eye-tracking tasks (Huettig & Altmann, 2005). Observing Figure 5.4 it is clear that, in keeping with prior research, semantic competition does not begin to manifest until around 300ms after target onset; the point with which the proportion of fixations on the target, competitor, and distractor begin to diverge. Such results could explain why there were a larger proportion of fixations on the competitor than the distractor as time went on in the present set of analyses. But, more than this, these results could suggest that any effect of semantic competition might be more stable at a region beginning 300ms after target onset until the offset of the spillover region ('is'). As such, the same analyses employed here were carried out on a region beginning 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is') in an attempt to isolate any effects of semantic competition across conditions.

5.1.3.2. Analyses 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is')

5.1.3.2.1. Looks on the target (lock), competitor (key), and distractor (ball, melon) in the Together condition

Similar analyses to those carried out for the transformed proportion of fixations on the target, competitor, and distractor in the Together condition 200ms after the onset until 200ms after the offset of the critical noun ('lock') (i.e. Section 5.1.3.1.1) were carried out here, for the Together condition 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is'). The average proportion of fixations on these regions in the Together condition is shown in Figure 5.13.

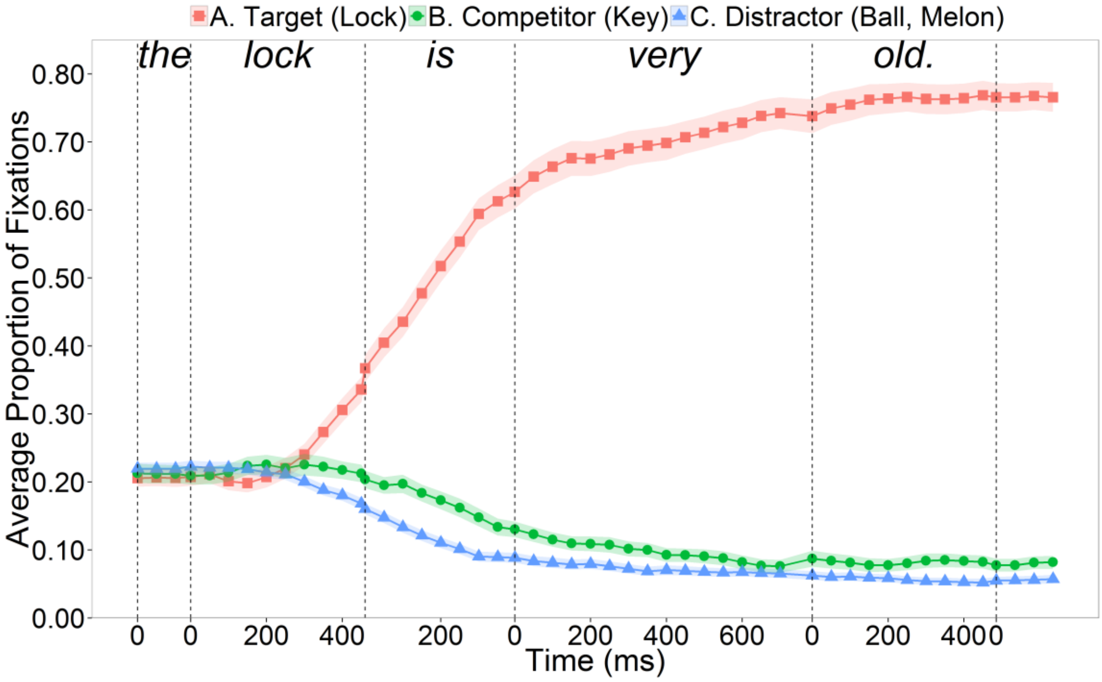


Figure 5.13. Average proportion of fixations on the target (lock), skateboard (key), and distractor (ball, melon) by participants (N=60) in the Together condition in Experiment 7; shaded bands show standard error

Table 5.11 shows the mean proportion of fixations and *SD* for the analysed region 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is'). The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

Table 5.11. Means and standard deviations for the proportion of fixations on the target (lock), competitor (key), and distractor (ball, melon) 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is') in the Together condition in Experiment 7

Interest Area	*M*	*SD*
Target (lock)	0.426	0.205
Competitor (key)	0.193	0.108
Distractor (ball, melon)	0.140	0.072

Inspection of the observed transformed data in Figure 5.14 revealed a linear change in the transformed proportion of fixations on each interest area during the analysed time-window, hence time was modelled as a fixed factor using orthogonal linear polynomials (i.e. instead of higher-order polynomials; see Mirman et al., 2008).

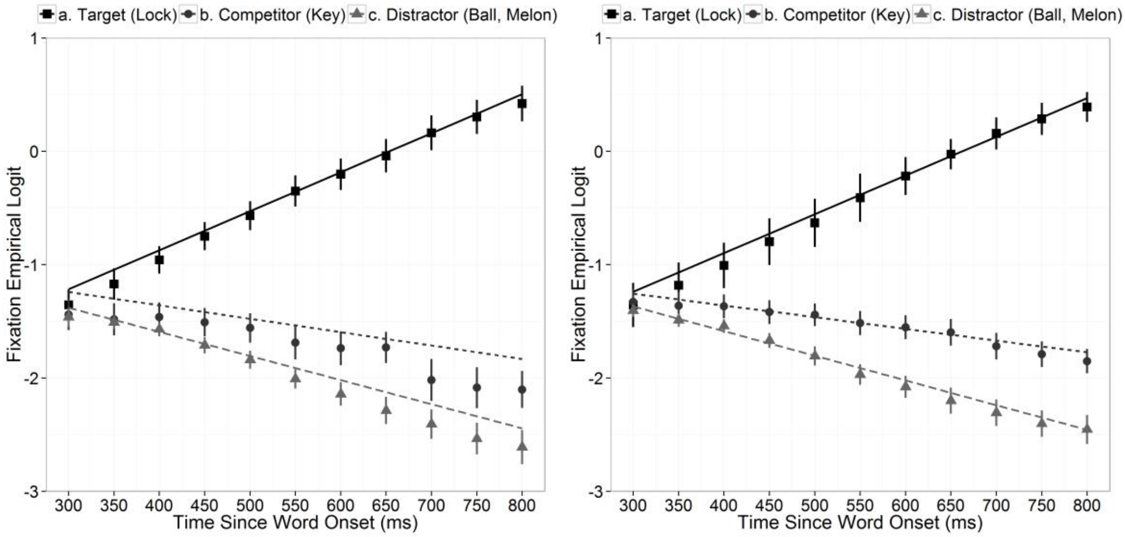


Figure 5.14. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=32) to the target (lock), competitor (key), and distractor (ball, melon) 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is') in the Together condition in Experiment 7; point-ranges represent the empirical logit and their standard errors

The same models and methods used to analyse the transformed proportion of fixations on each interest area in Section 5.1.3.1.1 were used here. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 5.12.

Table 5.12. By-participants [1] (N=60) and by-items [2] (N=32) parameter estimates for the comparisons between the transformed fixations on the target (lock), competitor (key), and distractor (ball, melon) 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is') in the Together condition in Experiment 7

Contrast	*β*	*SE*	z-value	Pr(>|z|)
Target vs. Competitor [1]				
Intercept	-1.180	0.124	-9.529	<.001***
Linear	-2.425	0.161	-15.083	<.001***
Target vs. Competitor [2]				
Intercept	-1.131	0.145	-7.800	<.001***
Linear	-2.333	0.179	-13.046	<.001***
Target vs. Distractor [1]				
Intercept	-1.556	0.124	-12.564	<.001***
Linear	-2.921	0.161	-18.121	<.001***
Target vs. Distractor [2]				
Intercept	-1.529	0.145	-10.537	<.001***
Linear	-2.934	0.180	-16.329	<.001***
Competitor vs. Distractor [1]				
Intercept	-0.376	0.124	-3.027	.014*
Linear	-0.496	0.163	-3.044	.013*
Competitor vs. Distractor [2]				
Intercept	-0.398	0.145	-2.744	.033*
Linear	-0.601	0.180	-3.336	.005**

****p*<.001; ***p* <.01; **p* <.05; $^{+}$.1< *p*<.05

Table 5.12 shows a significant difference between the target and competitor on the intercept and linear terms (all *p*s<.001), reflecting a larger proportion of fixations on the target throughout the entire time-window and as time goes on, respectively, when compared to the competitor in the Together condition. Similar findings are reported for the comparison between the target and distractor on the intercept and linear terms (all *p*s <.001), indicating that the target receives a larger proportion of fixations throughout the entire time-window and as time goes on when compared to the distractor in the Together condition. There is also a significant difference between the competitor and distractor on the intercept (p_1=.014; p_2=.033) and linear (p_1=.013; p_2=.005) terms, reflecting a larger proportion of fixations on the competitor throughout the entire time-window and as time goes on, respectively, when compared to the distractor in the Together condition.

5.1.3.2.2. Looks on the target (lock), competitor (key), and distractor (ball, melon) in the Apart condition

Similar analyses to those carried out for the transformed proportion of fixations on the target, competitor, and distractor in the Apart condition 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) (i.e. Section 5.1.3.1.2) were carried out here, for the Apart condition 300ms after the onset of the critical noun (‘lock’) until the offset of the spillover region (‘is’). The average proportion of fixations on these regions in the Apart condition is shown in Figure 5.15.

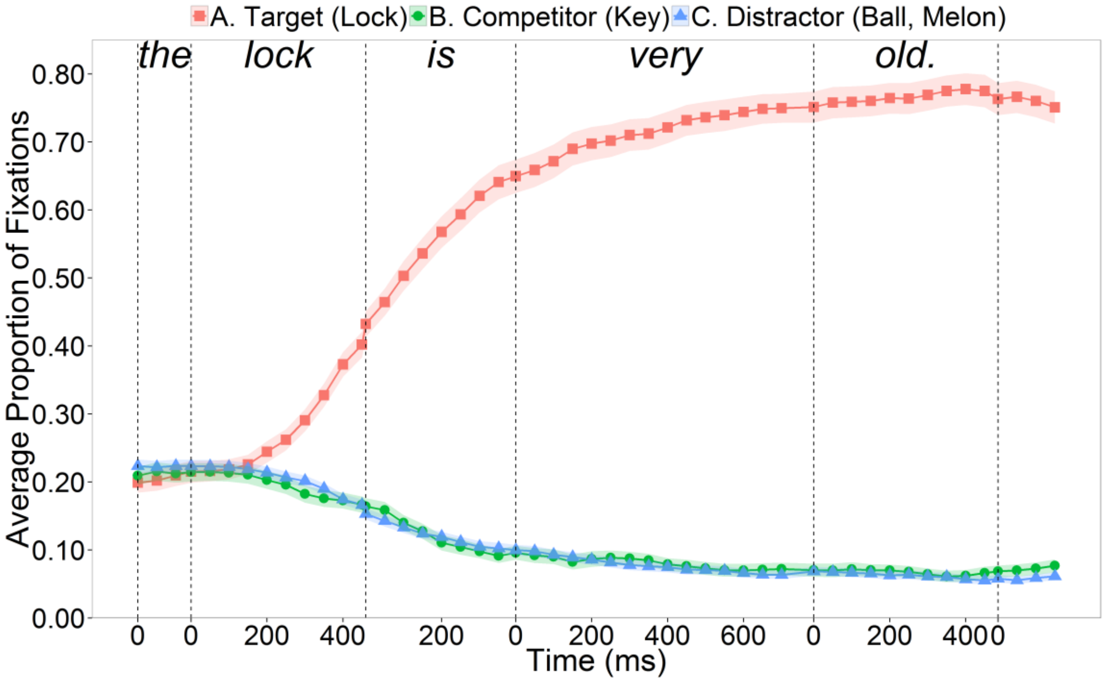


Figure 5.15. Average proportion of fixations on the target (lock), skateboard (key), and two distractors (ball, melon) by participants (N=60) in the Apart condition in Experiment 7; shaded bands show standard error

Table 5.13 shows the mean proportion of fixations and *SD* for the analysed region, 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is'). The data reported here were transformed using the method outlined in Section 2.2.2.1, with a full report of the specific approach outlined below.

Table 5.13. Means and standard deviations for the proportion of fixations on the target (lock), competitor (key), and distractor (ball, melon) 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is') in the Apart condition in Experiment 7

Interest Area	*M*	*SD*
Target (lock)	0.478	0.200
Competitor (key)	0.142	0.090
Distractor (ball, melon)	0.146	0.070

Inspection of the observed transformed data in Figure 5.16 revealed one point of inflection in the transformed proportion of fixations on each interest area during the analysed time-window, as such second-order (quadratic) orthogonal polynomials were preferred over lower-order orthogonal polynomials in this analysis (e.g. Mirman et al., 2008).

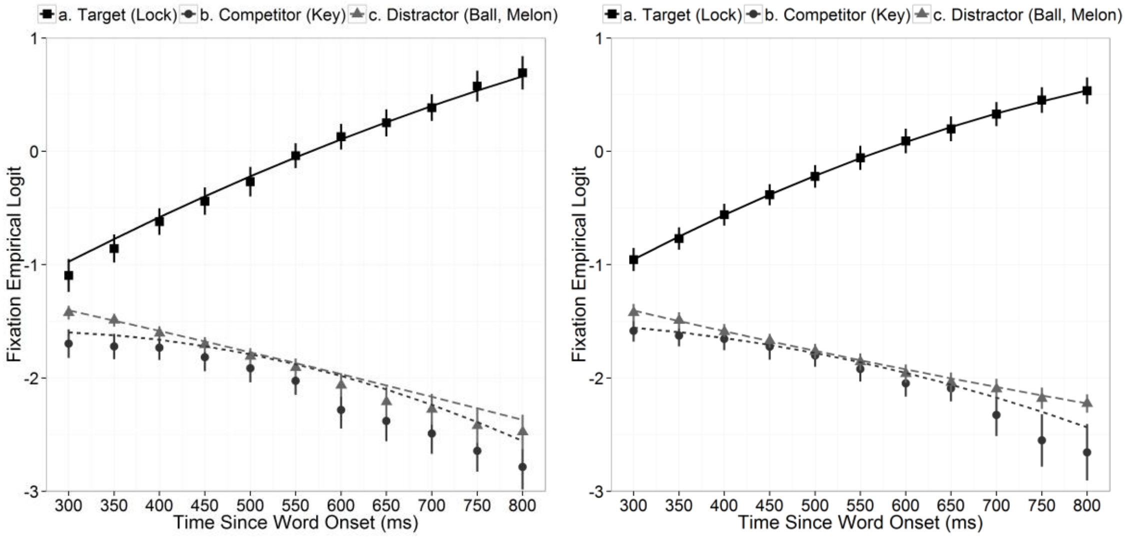


Figure 5.16. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=32) to the target (lock), competitor (key), and distractor (ball, melon) 300ms after the onset of the critical noun (‘lock’) until the offset of the spillover region (‘is’) in the Apart condition; point-ranges represent the empirical logit and their standard errors in Experiment 7

Similar models and methods used to analyse the transformed proportion of fixations on each interest area in Section 5.1.3.1.2 were used here, with the only change involving the inclusion of the higher-order (quadratic) time term. Specifically, both models contained fixed effects of the orthogonal linear and quadratic time terms and interest area on the intercept and slopes. This model also used a maximal converging random effects structure (Barr et al., 2013), with random effects of participants and participants nested within interest area on the intercept and slope terms for the by-participants analysis, and with random effects of item and item nested within interest area on the intercept and slope terms for by-items analysis. For full model examples, see Appendix F.3. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 5.14.

Table 5.14. By-participants [1] (N=60) and by-items [2] (N=32) parameter estimates for the comparisons between the transformed fixations on the target (lock), competitor (key), and distractor (ball, melon) 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is') in the Apart condition in Experiment 7

Contrast	*β*	*SE*	z-value	Pr(>|z|)
Target vs. Competitor [1]				
Intercept	-1.863	0.119	-15.666	<.001***
Linear	-2.719	0.210	-12.935	<.001***
Quadratic	-0.112	0.100	-1.107	.865
Target vs. Competitor [2]				
Intercept	-1.796	0.116	-15.451	<.001***
Linear	-2.484	0.196	-12.651	<.001***
Quadratic	0.017	0.099	0.167	1.00
Target vs. Distractor [1]				
Intercept	1.781	0.119	-15.011	<.001***
Linear	-2.729	0.209	-13.081	<.001***
Quadratic	0.102	0.099	1.029	.899
Target vs. Distractor [2]				
Intercept	-1.713	0.116	-14.753	<.001***
Linear	-2.423	0.195	-12.410	<.001***
Quadratic	0.205	0.098	2.099	.242
Competitor vs. Distractor [1]				
Intercept	0.082	0.119	0.688	.985
Linear	-0.010	0.212	-0.047	1.00
Quadratic	0.212	0.102	2.075	.247
Competitor vs. Distractor [2]				
Intercept	0.083	0.116	0.713	.984
Linear	0.061	0.197	0.310	1.00
Quadratic	0.189	0.101	1.872	.372

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 5.14 shows a significant difference between the target and competitor on the intercept and linear terms (all *p*s<.001), reflecting a larger proportion of fixations on the target object throughout the entire time-window and as time goes on, respectively, when compared to the competitor in the Apart condition. Similar findings are reported for the comparison between the target and distractor on the intercept and linear terms (all *p*s<.001), indicating that the target receives a larger proportion of fixations throughout the entire time-window and as time goes on when compared to the distractor in the Apart condition. For the comparison between the competitor and distractor, there is no significant difference between the proportion of fixations on the two objects on the intercept or linear terms (all *p*s >.05). This indicates that there is no difference in the proportion of fixations on the competitor and distractor throughout the entire time-window and as time goes on in the Apart condition.

5.1.3.2.3. Comparing looks on the target (lock) in the Together vs. Apart conditions

Similar analyses to those carried out for the transformed proportion of fixations on the target (lock) 200ms after the onset until 200ms after the offset of the critical noun ('lock') across the two conditions (i.e. Section 5.1.3.1.3) were carried out here for the target (lock) 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is'). The average proportion of fixations on the target across conditions is shown in Figure 5.17. Here, the target receives a numerically larger proportion of fixations in the Apart condition (*M*=0.478, *SD*=0.200) when compared to the Together condition (*M*=0.426, *SD*=0.205).

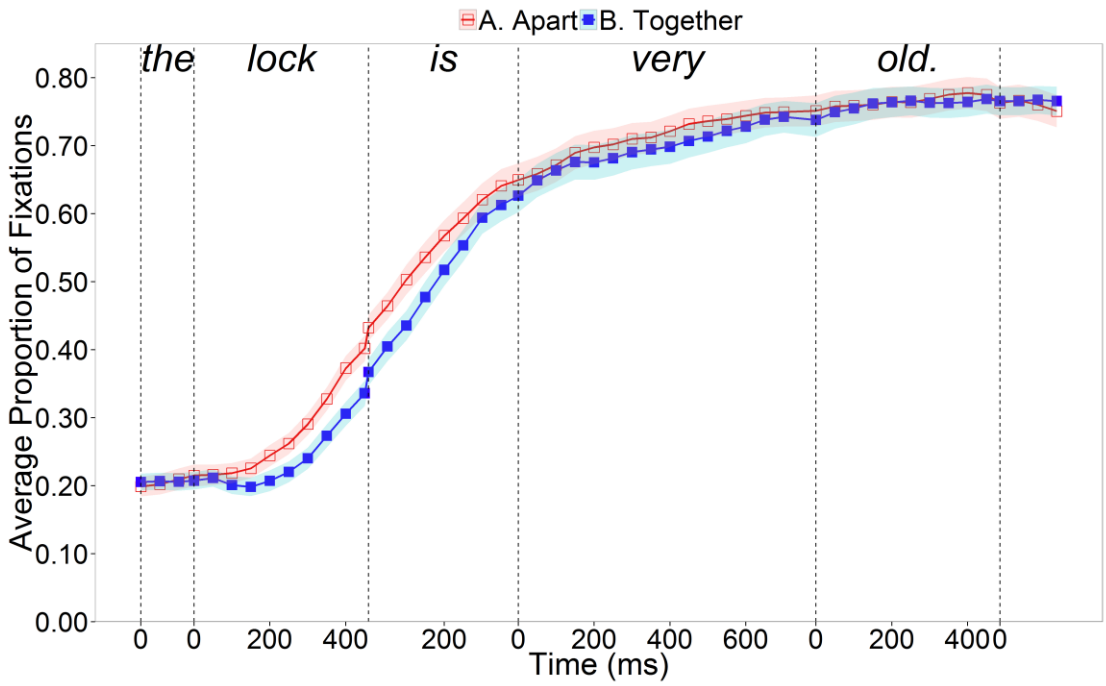


Figure 5.17. Average proportion of fixations on the target (lock) by participants (N=60) in the Apart and Together conditions in Experiment 7; shaded bands show standard error

Two models were created and run separately for by-participants and by-items analyses respectively, exploring the main effect of condition on fixations over time. Inspection of the observed transformed data in Figure 5.18 revealed a linear change in the transformed proportion of fixations on the target (lock) during the analysed time-window, hence time was modelled as a fixed factor using orthogonal linear polynomials (i.e. instead of higher-order polynomials; see Mirman et al., 2008).

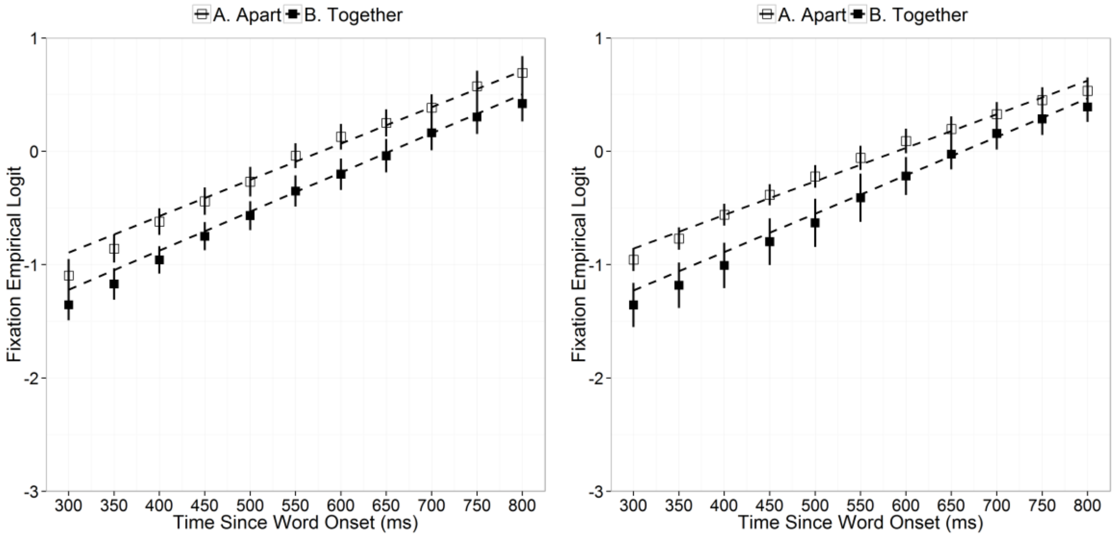


Figure 5.18. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=32) on the target (lock) in the Apart and Together conditions 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is') in Experiment 7; point-ranges represent the empirical logit and their standard errors

The same models and methods used to analyse the transformed proportion of fixations on the target across conditions (see Section 5.1.3.1.3) for the region 200ms after the onset until 200ms after the offset of the critical noun ('lock') were used in the analysis for the transformed proportion of fixations on the target across conditions during the region 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is'). For full model examples, see Appendix F.3. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 5.15.

Table 5.15. By-participants [1] (N=60) and by-items [2] (N=32) parameter estimates for the transformed fixations on the target (lock) 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is') in Experiment 7

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-0.091	0.100	-0.906	.365
Linear	1.684	0.123	13.665	<.001***
Together	-0.267	0.089	-3.001	.003**
Linear: Together	0.128	0.114	1.129	.259
By-items [2]				
Intercept	-0.117	0.111	-1.051	.293
Linear	1.553	0.124	12.508	<.001***
Together	-0.264	0.070	3.744	<.001***
Linear: Together	0.223	0.126	1.767	.077$^+$

****p*<.001; ***p* <.01; **p* <.05; $^+$.1< *p*<.05

Table 5.15 shows a significant difference between the Apart and Together conditions on the intercept term (p_1=.003; p_2<.001), showing a larger proportion of fixations on the target throughout the entire time-window in the Apart condition when compared to the Together condition. However, there is no significant difference between the two conditions on the linear term (p_1=.259; p_2=.077), indicating that as time goes on there in no change in the rate of increase in the proportion of fixations on the target across conditions.

5.1.3.2.4. Comparing looks on the competitor (key) in the Together vs. Apart conditions

Similar analyses to those carried out for the transformed proportion of fixations on the competitor (key) 200ms after the onset until 200ms after the offset of the critical noun ('lock') across the two conditions (i.e. Section 5.1.3.1.4) were carried out here for the competitor (key) 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is'). The average proportion of fixations on the competitor (key) across the two conditions is shown in Figure 5.19. Here, the competitor receives a numerically larger proportion of fixations in the Together condition (*M*=0.192, *SD*=0.108) when compared to the Apart condition (*M*=0.142, *SD*=0.090).

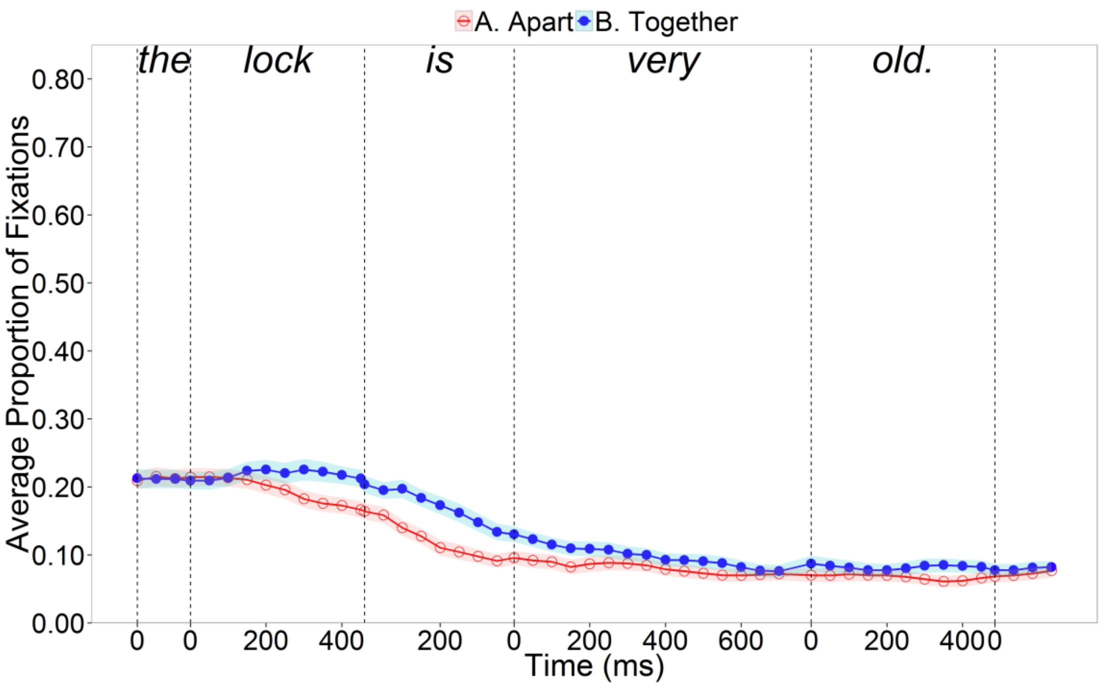


Figure 5.19. Average proportion of fixations on the competitor (key) by participants (N=60) in the Apart and Together conditions in Experiment 7; shaded bands show standard error

Two models were created and run separately for by-participants and by-items analyses respectively, exploring the main effect of condition on fixations over time. Inspection of the observed transformed data in Figure 5.20 revealed one point of inflection in the transformed proportion of fixations on the competitor (key) throughout the analysed time-window; as such second-order (quadratic) orthogonal polynomials were preferred over lower-order orthogonal polynomials in this analysis (e.g. Mirman et al., 2008).

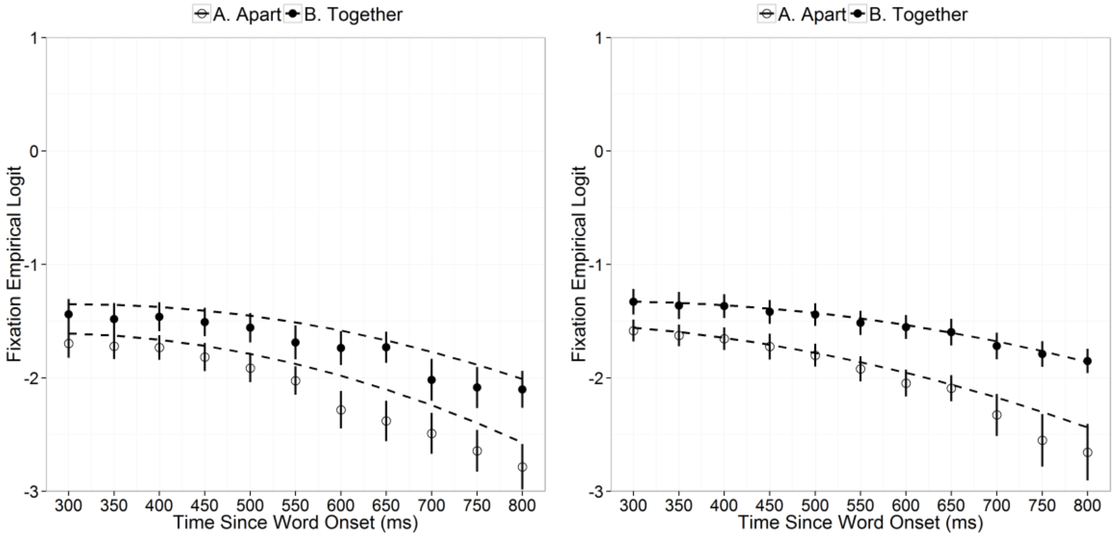


Figure 5.20. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=32) on the competitor (key) in the Apart and Together conditions 300ms after the onset of the critical noun (‘lock’) until the offset of the spillover region (‘is’) in Experiment 7; point-ranges represent the empirical logit and their standard errors

The same models and methods used to analyse the transformed proportion of fixations on the competitor across conditions (see Section 5.1.3.1.4) for the region 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) were used in the analysis for the transformed proportion of fixations on the competitor across conditions during the region 300ms after the onset of the critical noun (‘lock’) until the offset of the spillover region (‘is’). For full model examples, see Appendix F.3. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 5.16.

Table 5.16. By-participants [1] (N=60) and by-items [2] (N=32) parameter estimates for the transformed fixations on the competitor (key) 300ms after the onset of the critical noun (‘lock’) until the offset of the spillover region (‘is’) in Experiment 7

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-1.961	0.091	-21.528	<.001***
Linear	-1.008	0.160	-6.289	<.001***
Quadratic	-0.249	0.087	-2.853	.004**
Together	0.382	0.121	3.167	.002**
Linear: Together	0.318	0.193	1.647	.100
Quadratic: Together	0.049	0.112	0.438	.661
By-items [2]				
Intercept	-1.916	0.091	-20.964	<.001***
Linear	-0.923	0.162	-5.711	<.001***
Quadratic	-0.158	0.086	-1.834	$.067^{+}$
Together	0.393	0.094	4.162	<.001***
Linear: Together	0.365	0.189	1.930	$.054^{+}$
Quadratic: Together	0.019	0.119	0.159	.874

***p<.001; **p <.01; *p <.05; $^{+}$.1< p<.05

Table 5.16 shows a significant difference between the Apart and Together conditions on the intercept term (p_1=.002; p_2<.001), showing a larger proportion of fixations on the competitor throughout the entire time-window in the Together condition when compared to the Apart condition. However, there is no significant difference between the two conditions on the linear (p_1=.100; p_2=.054) term, indicating that as time goes on there in no change in the rate of increase in the proportion of fixations on the competitor across conditions.

5.1.3.2.5. Comparing looks on the distractor (ball, melon) in the Together vs. Apart conditions

Similar analyses to those carried out for the transformed proportion of fixations on the distractor (ball, melon) 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) across the two conditions (i.e. Section 5.1.3.1.4) were carried out here for the distractor (ball, melon) 300ms after the onset of the critical noun (‘lock’) until the offset of the spillover region (‘is’). The average proportion of fixations on the distractor (ball, melon) across the two conditions is shown in Figure 5.21. Here, the distractor receives a numerically larger proportion of fixations in the Apart condition (*M*=0.146, *SD*=0.070) when compared to the Together condition (*M*=0.140, *SD*=0.072).

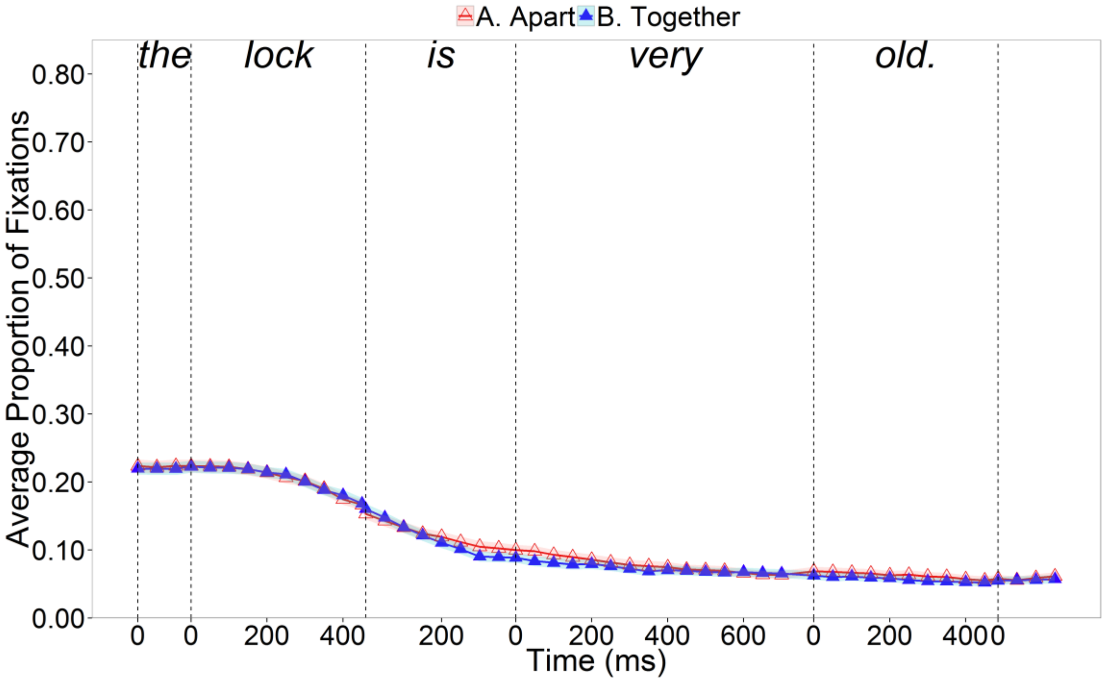


Figure 5.21. Average proportion of fixations on the distractor (ball, melon) by participants (N=60) in the Apart and Together conditions in Experiment 7; shaded bands show standard error

Two models were created and run separately for by-participants and by-items analyses respectively, exploring the main effect of condition on fixations over time. Inspection of the observed transformed data in Figure 5.22 revealed a linear change in the transformed proportion of fixations on the distractor (ball, melon) during the analysed time-window, hence time was modelled as a fixed factor using orthogonal linear polynomials (i.e. instead of higher-order polynomials; see Mirman et al., 2008).

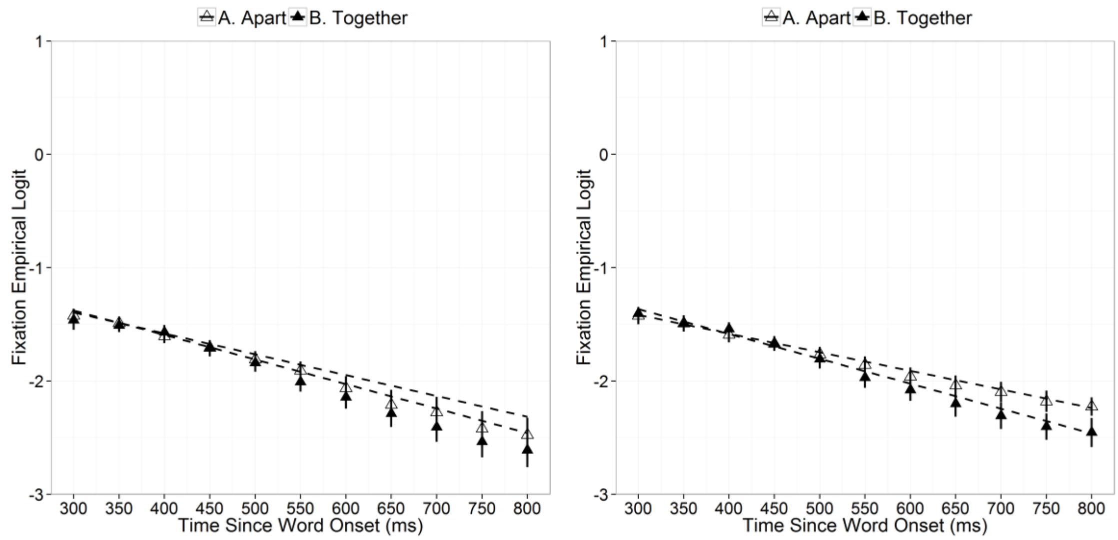


Figure 5.22. Model fits and fixations (transformed data) by participants (Left; N=60) and items (Right; N=32) on the distractor (ball, melon) in the Apart and Together conditions 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is') in Experiment 7; point-ranges represent the empirical logit and their standard errors

The same models and methods used to analyse the transformed proportion of fixations on the distractor across conditions (see Section 5.1.3.1.5) for the region 200ms after the onset until 200ms after the offset of the critical noun ('lock') were used in the analysis for the transformed proportion of fixations on the distractor across conditions during the region 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is'). For full model examples, see Appendix F.3. Parameter estimates for all contrasts across both by-participants and by-items analyses are shown in Table 5.17.

Table 5.17. By-participants [1] (N=60) and by-items [2] (N=32) parameter estimates for the transformed fixations on the distractor (ball, melon) 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is') in Experiment 7

	Est.	*SE*	*t*	*p*
By-participants [1]				
Intercept	-1.856	0.065	-28.565	<.001***
Linear	-0.965	0.113	-8.562	<.001***
Together	-0.063	0.078	-0.799	.424
Linear: Together	-0.169	0.137	-1.235	.217
By-items [2]				
Intercept	-1.828	0.070	-26.189	<.001***
Linear	-0.862	0.108	-8.003	<.001***
Together	-0.086	0.058	-1.482	.138
Linear: Together	-0.289	0.133	-2.163	.031*

****p*<.001; ***p* <.01; **p* <.05; $^{+}$.1< *p*<.05

Table 5.10 shows no significant difference between the Apart and Together conditions on the intercept term (p_1=.424; p_2=.138) and a non-reliable difference between the two conditions on the linear term (p_1=.217; p_2=.031), indicating that there is no difference between the two conditions in the proportion of fixations on the distractor either throughout the entire time-window or as time goes on, respectively.

5.1.3.3. Overall summary of results

The results of the current experiment show that both 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) and 300ms after the onset of the critical noun (‘lock’) until the offset of the spillover region (‘is’), the target object (lock) received a larger proportion of fixations than the competitor (key) and distractor (ball, melon) throughout the entire time-window and as time went on (linearly) in both conditions. Two-hundred milliseconds after the onset until 200ms after the offset of the critical noun (‘lock’), while there was no difference in the proportion of fixations allocated to the competitor and distractor throughout the entire time-window in both the Together and Apart conditions, the competitor received a larger proportion of fixations than the distractor as time went on (linearly) in the Together condition, but not in the Apart condition. Three-hundred milliseconds after the onset of the critical noun (‘lock’) until the offset of the spillover region (‘is’), the competitor received a larger proportion of fixations than the distractor both throughout the entire time-window and as time went on in the Together condition. However, there was no difference in the proportion of fixations allocated to the competitor and distractor both throughout the entire time-window and time went on in the Apart condition.

During both regions of analysis, a direct comparison of the proportion of fixations on each interest area across conditions revealed that the target received a larger proportion of fixations in the Apart condition than the Together condition throughout the entire time-window only. An inverse pattern of results was observed for the competitor; during both regions of analysis the competitor received a larger proportion of fixations in the Together condition than the Apart condition throughout the entire time-window only. Moreover, in both regions of analysis the proportion of fixations on the distractor did not differ across conditions. Together, these results suggest that during the noun region, there is a significant increase in the proportion of fixations on the competitor when compared to the distractor in the Together condition only. However, for the region 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) there was a marginally significant difference between the two conditions on the linear term for the competitor, showing that the rate of access for the competitor was (marginally) faster in the Together condition when compared to the Apart condition. In both regions of analysis, there was no significant difference in the proportion of fixations on the distractor across conditions.

Together, the present findings suggest that the competitor is accessed more rapidly than the distractor 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) in the Together condition only, and that this effect is stable throughout the entire time-window 300ms after the onset of the critical noun (‘lock’) until the offset of the spillover region (‘is’); a region including an onset consistent with semantic competition in prior studies (Huettig & Altmann, 2005; Yee & Sedivy, 2006). While the first region of analysis shows that the competitor becomes more accessible than the distractor as time goes on in the Together condition only, the second analysis shows that this semantic competition effect is persistent across an entire region in which semantic competition is thought to begin. Moreover, observing the differences in conditions in regards to the proportion of fixations on each object across both regions of analysis, because the competitor receives a larger proportion of fixations in the Together condition than the Apart condition, the target receives a lower proportion of fixations in the Together condition when compared to the Apart condition, and the proportion of fixations on the distractor do not differ, presumably the competitor receives a larger proportion of fixations in the Together condition at a cost to fixations on the target. Thus, it can be concluded that not only is semantic competition stronger in the Together condition than the Apart condition, but this is the only case in which semantic competition occurs in the present experiment. The implications for these results are discussed in Section 5.1.4.

5.1.4. Discussion

The present study was designed to address two main questions: (1) Is information in the working event model more accessible than information in a backgrounded event model? (2) Can event structure improve accessibility for a target? While this first question is seemingly redundant given the range of studies showing robust effects of foregrounding (Glenberg et al., 1987; Rinck & Bower, 1995, 2000; Rinck et al., 1997) – a higher level of accessibility for information in the same location as a protagonist – all of these studies have relied upon a paradigm in which narratives describe a protagonist either staying in one location or moving to another before making reference to an object in the initial location. These studies have typically shown that when the target is in a different location to the protagonist it is less accessible than if it was in the same location as the protagonist. The Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) claims that this is because information in the working event model (i.e. the same event model as the protagonist) is more accessible as it is maintained in working memory. While it is clear that the target is less accessible when in a different location to the target because it is not (initially) foregrounded, a further cost to accessing the object is the need to switch focus from one event model to another in order to retrieve the target. As such, teasing apart the bias in accessibility for information in the working event model from a cost to switching focus from one event model to another is necessary in order to observe effects of a bias in terms of accessibility for 'pure' foregrounding only. Using a semantic competitor, it was possible to observe the baseline level of accessibility for information maintained in the working and backgrounded event models without any requirement for switching focus from one event model to another. In this case, it was assumed that on mention for the target, only the event model containing the target would become foregrounded. As such, we can observe the levels of accessibility for a semantic competitor in cases where the competitor is maintained in the working (foregrounded) event model or not, thus observing any effect of 'pure' foregrounding. Moreover, because the Event Horizon model claims that information in the working event model is more accessible than information outside of the working event model, it was deemed necessary to test whether this claim extends to information that is not directly probed for on access.

The second question was concerned with whether maintaining a (typically) competitive source of information in a separate event model to a target can improve accessibility for the target. This was inspired by recent research by Pettijohn et al. (2016) who showed that event structure can be used to improve memory for non-competitive sources of information. Here, Pettijohn et al. found that memorising a list across two separate locations improves overall memory for items on the list, presumably by adding structure to those items and reducing the number of items maintained within one event model that could compete on access. Because this is one of the few studies exploring the positive aspects of event structure on memory for information, i.e. how representing information across multiple event models can improve memory, the present experiment was concerned with exploring cases in which event structure can also be used to improve memory for information; but in this case during a naturalistic language processing task. Similarly to Pettijohn et al. (2016), it was predicted that maintaining information across multiple event models would provide structure to those sources of information. However, in the present study, because only one source of information, the target, was required to be accessed, it was hypothesised that only this event model would be accessed on mention. Thus, it was assumed that describing the target and competitor in the same location would establish these two objects as being maintained in the same event model. In cases where the target and competitor were described as being in separate locations, it was assumed that these objects would be maintained in separate event models. In both cases, on mention for the target, the event model containing the target should already be, or otherwise become, foregrounded, increasing accessibility for information maintained within this event model, and reducing accessibility for information maintained outside of this event model. Thus, on mention for the target, it was hypothesised that semantic competition would only occur (or would be strongest) when the target and competitor were in the same event model (i.e. Together condition), but would not occur (or would be weaker) when the two were maintained in separate event models (i.e. Apart condition).

Two-hundred milliseconds after the onset until 200ms after the offset of the critical noun (‘lock’) the target (lock) received a larger proportion of fixations than the semantically-related competitor (key) and the mean of the two distractors (ball, melon). During this same region, the competitor received a larger proportion of fixations than the distractor as time went on in the Together condition, however there was no difference in the proportion of fixations on the competitor and distractor in the Apart condition. These findings suggest that 200ms after the onset until 200ms after the offset of the critical noun (‘lock’) there is no semantic competition in the Apart condition. However, while there is also no semantic competition throughout the entire time-window in the Together condition, as time went on the competitor received a larger proportion of fixations than the distractor. Such a finding is consistent with the timing of semantic competition in previous eye-tracking experiments (e.g. Huettig & Altmann, 2005; Yee & Sedivy, 2006). For example, for Yee and Sedivy, the increase in the proportion of fixations on the competitor began around 200ms after the onset of the critical noun, steadily rising until around 300ms before levelling off, while receiving a consistently larger proportion of fixations than the distractor until around 900ms after the onset of the critical noun. Bearing this in mind, when comparing the proportion of fixations on each object 300ms after the onset of the critical noun ('lock'), i.e. the point at which the proportion of fixations on each object diverges in the present experiment, until the offset of the spillover region ('is'), there was a consistently larger proportion of fixations on the competitor than the distractor in the Together condition throughout the entire time-window, showing robust effects of competition across a time-frame consistent with previous research (e.g. Huettig & Altmann, 2005; Yee & Sedivy, 2006). Again, there was no difference in the proportion of fixations on the competitor and distractor in the Apart condition. In both regions of analysis the target received a larger proportion of fixations in the Apart condition when compared to the Together condition, while the competitor received a larger proportion of fixations in the Together condition when compared to the Apart condition. Finally, there was no difference in the proportion of fixations on the distractor across both conditions. These results suggest that maintaining a target and competitor in separate event models not only reduces, but eradicates the amount of semantic competition on access for the target. Whereas when the target and competitor are maintained in the same event model, competition occurs on access for the target, causing a trade-off in the proportion of fixations on the target as a result. As such, maintaining a competitor in a backgrounded event model acts to reduce the accessibility for the competitor, thereby increasing accessibility for the target.

Addressing the first aim of the present experiment – to explore whether foregrounding occurs irrespective of the need for a shift in attention from one event model to another – the present findings show a clear bias in terms of accessibility for information maintained in the same event model as the target. In both conditions, half of the items mentioned the location of the target (and the target) in the first sentence, while the other half mentioned the location of the target (and the target) in the second sentence. Regardless of condition, it is likely that the most recently mentioned location would be foregrounded prior to mention of the target. However, on mention of the target, the event model containing the target is likely to become foregrounded. Thus, in both conditions where the target is mentioned in the first sentence this would require a shift of focus from one event model to another. Whereas in both conditions in which the target is mentioned in the last sentence, no shift would be required as the event model containing the target would already be foregrounded. Averaging across these items, both conditions contain cases where a shift in attention must occur and a shift in attention needn't occur in order to access the target. Thus, the increased accessibility for a semantic competitor when in the same location as the target is likely driven by foregrounding, irrespective of a shift in attention often elicited from previous experiments that have explored foregrounding (Glenberg et al., 1987; Rinck & Bower, 1995, 2000).

Given that Experiment 3 of the present thesis failed to show any main effect of foregrounding on accessibility for a target, we must ask why, contrary to Experiment 3, the present experiment shows an effect of foregrounding. As noted in Section 5.1.1, it is possible that in Experiment 3, explicitly stating both locations prior to mention of the target may have resulted in participants failing to foreground any one location prior to mention of the target, or alternatively maintaining both locations in working memory. If so, accessibility for the target would be equivalent across the four sentential conditions. Moreover, in Experiment 3, the narratives were relatively long and complex, introducing several objects, characters, locations, and actions. Given the complexity of the narrative, it is possible that participants found it difficult to adopt any one perspective during comprehension. But, most crucially, in Experiment 3 the sentential stimuli confounded recency of mention with foregrounding, and as such recency of mention may have masked any effects of foregrounding. In contrast, the present experiment introduced only two locations and four objects in relatively short and simple narratives and counterbalanced recency of mention with foregrounding. In such cases, it is likely that an event model would be relatively easy to construct and maintain, resulting in a readily observable influence of foregrounding on accessibility for information within the narrative, but most importantly we can attribute the findings of the present experiment to foregrounding without recourse to recency of mention.

One further interesting finding in the present experiment, as a result of the simple narrative structure, is the fact that foregrounding effects occur even in the absence of the introduction of a protagonist within the narrative. As Wilson, Rinck, and McNamara

(1993) note, if a protagonist is not included in a set of probes, we are unlikely to observe any influence of the spatial-temporal framework on accessibility for information within the narrative. However, as evidenced by the body of work in the present thesis, accessibility for information within a narrative is influenced by the spatial-temporal framework of the model on mention for a target only. Still, all of the previous experiments in this thesis are reliant upon comprehenders adopting the perspective of a protagonist, with accessibility for information within the narrative dependent upon the relationship of the protagonist and target within a particular spatial-temporal framework. Indeed, while various studies have shown that accessibility for information within a narrative is often dependent upon the perspective taken during comprehension (e.g. Bower & Morrow, 1989; Glenberg et al., 1987; Rinck & Bower, 1995), we are not necessarily reliant upon a fixed perspective from a protagonist when forming and using event models; instead we can take non-fixed perspectives, with accessibility for information dependent upon the immediate goals of the comprehender (Albrecht et al., 1995; Rapp et al., 2006). Thus, the present experiment shows an influence of event model structure on accessibility for information regardless of the presence of a protagonist within the narrative.

The most crucial finding of the present experiment in regards to foregrounding is that information in the working event model is immediately more accessible than information outside of the working event model on access. As this bias in accessibility cannot be attributed to a mismatch in the need to switch attention from one event model to another, this suggests that the baseline of accessibility for information maintained within a foregrounded event model is higher than information outside of it. Importantly, and in-keeping with the claims of the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012), this bias is applicable to information not directly probed-for, in that the competitor is more accessible when in the working event model (vs. the backgrounded event model). Along with the findings of Experiments 3 and 4-6, showing that a spatial shift reduces accessibility for information even if this piece of information is foregrounded, these series of experiments have shown that the effects of foregrounding and spatial shifts are indeed separate to one-another, providing further evidence in support of the claims of the Event Horizon model, but showing that these effects are immediate during narrative comprehension, and occur in relatively naturalistic tasks.

Addressing the second aim of the present experiment – to explore whether event structure can improve accessibility for a target on access – the results show that maintaining a competitive source of information in a separate event model to the target reduces the amount of competition exhibited on access for the target, improving accessibility for the target. In this way, segmenting competitive information in separate event models can reduce interference from the competitive source of information, improving accessibility for a target, showing a positive influence of event segmentation on accessibility for information. While addressing a similar aim as Pettijohn et al. (2016), the two studies differ in how they address the notion that representing information across multiple event models can improve accessibility for that information during non-competitive retrieval. Pettijohn et al. observed how providing structure to the items on a list, i.e. memorising the entire list in one location, or each half in separate locations, can improve overall memory for items on the list. In their study, accessibility for information was addressed in entirely non-competitive circumstances as each item on the list was only represented in one event model. Similarly, in the present study, each piece of information (e.g. object) was only represented in one event model. Thus, in both cases access for the target occurs in a non-competitive circumstance in regards to which event model must be accessed. However, in Pettijohn et al. both event models were required to be accessed, whereas in the present study accessibility for the target was dependent upon capitalising on this segmentation, and the idea that we access only one event model at a time (Radvansky, 2012), in order to remove otherwise competitive information (e.g. semantic competitor) from the same event model as the target, thereby improving accessibility for the target. As such, while Pettijohn et al. show that accessibility for information can be improved by providing structure to a memorised list, likely by reducing retroactive interference, the present study shows that accessibility for information can be improved by removing competitive information from the same event model as the target. Together, the present study, along with Pettijohn et al., show that event structure and event segmentation can benefit accessibility for information under circumstances involving non-competitive retrieval for an event model containing a target.

The present experiment shows that maintaining a target and different-object competitor in separate event models reduces the amount of interference found when accessing the target (vs. when both objects are in the same event model). This result differs from Experiments 4 and 5, in that in these experiments maintaining a target and same-object competitor in separate event models increased the amount of interference found when accessing the target (e.g. the object in the final location). The reason for the difference in the direction of effect across Experiments 4 and 5 and the present experiment is likely due to the type of competitor. In Experiments 4 and 5, the competitor (i.e. source) was another instantiation of the target (i.e. goal). As such, when accessing the target, conflict occurs in regards to what the name of the target refers to; the instantiation of the object in the initial location (competitor) or the instantiation of the object in the final location (target). In cases where the target and competitor are in separate event models, both instantiations of the object are likely less accessible due to some process of event selection, in which one event model must be brought to the foreground on mention of the target. Whereas when both instantiations are in the same event model, no event selection need take place. Yet, if the competitor is a different object to the target, as in the present experiment, on mention for the target this name only refers to the target, and thus does not prompt for access for, or consideration of, the competitor. Regardless of whether the target and competitor are in the same or separate event models, only one event model is relevant to the target object, and as such only this event model will be accessed. As such, no event selection need occur in the present experiment. But, because information in the working event model is typically more accessible than information maintained outside of the working model, the competitor should be more accessible when in the same event model as the target when this event model becomes foregrounded (vs. when in a different event model). Thus, while competition occurs in Experiments 4 and 5 when the target (goal) and competitor (source) are maintained in separate event models, competition occurs in the present experiment when the target (lock) and competitor (key) are maintained in the same event model. As such, the present experiment supports the notion that event selection might be the process at play in Experiments 4 and 5, by which accessibility for a target object (and competitor) is reduced when the object is related to more than one event model; again, a claim laid out by the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012).

Some further implications of the current work relate directly to the automaticity with which linguistic context can be considered on lexical access, and how this influences access for the semantic information about objects within the narrative/visual display. In the situation model literature, the granularity in the type of spatial representation formed (i.e. whether or not we can represent and/or use Euclidean distance) is dependent upon whether the task at hand requires this metric of space for completion (Rinck et al., 1997), a finding further echoed in general spatial cognition tasks concerned with evaluating the spatial relations amongst objects (McNamara, 1986). Taking into account research by Hanna, Tanenhaus, and Trueswell (2003) and Sedivy, Tanenhaus, Chambers, and Carlson (1999), showing that we rapidly utilise extra-linguistic and linguistic context to round down the number of candidates that might be referred to in a language processing task, it stands to bear that spatial information – specifically, described locations of objects within a narrative – may influence what is accessed on mention of the target. Because the most salient feature of the narrative in the present experiment was a description of the spatial belonging of each of the four objects, and specifically which objects belonged together in a given location, it is likely that this information would be considered when attempting to access the target. Interestingly, while the semantic and/or associative similarity between the target and competitor is also highly salient, the spatial description of the target and competitor seemingly mediates the amount of semantic competition between the two objects. Thus, spatial context within the event model is immediately considered in light of the unfolding narrative and dictates whether semantic information is accessed. Lexical access in this case is therefore dependent upon higher-level language contexts.

Prior research has shown that activation of semantic competitors is unrestricted by visual context (Yee & Sedivy, 2006), yet recent research has established that task and linguistic context can modulate semantic priming. For example, in one experiment Yee, Ahmed, and Thompson-Schill (2012) have shown that colour priming in a semantic-judgment task (i.e. determining whether or not target words were animals) occurs between a target (e.g. cucumber) and prime (e.g. emerald) if a prior task draws attention to colour (e.g. a Stroop task (Stroop, 1935)), but not if this colour biasing task occurs after the semantic-judgment task. In a similar vein, when given a Stroop task involving object words that can take a typical and atypical colour (e.g. red for a ripe tomato, and green for an unripe tomato), reading a context sentence that implied one colour (e.g. ‘Jane tasted the tomato when/before it was ready to eat’) facilitated naming when the colour of the ink matched the implied colour of the object (Connell & Lynott, 2009). In both of these experiments, the prior or immediate context biased whether or not colour information, part of the semantics of a word, was accessed. It is possible that in the current experiment the linguistic context made the spatial arrangements of the objects a highly salient feature, perhaps prompting participants to track the spatial relations between the objects and to use a processing strategy reliant upon space, with this spatial information modulating semantic activation amongst the target and competitor. As access for colour information seems to be dependent upon context presumably because it can vary within categories of objects (e.g. the tomato can be either red or green) (e.g. Huettig & Altmann, 2011), perhaps more general semantic information is sensitive to other factors that vary, such as spatial context; why access knowledge about an object if it isn't relevant to the current spatial-temporal sequence of events?

While the present findings show how linguistic context can manipulate semantic competition, given the design of the materials in this experiment it is difficult to distinguish whether semantic competition only occurs when the target and competitor are in the same event model, or in the same sentence as one another (J. C. Trueswell, personal communication, September 5, 2015). Indeed, it is possible that throughout the present experiment participants did not rely upon an event model when understanding the discourse, but instead processed the narrative in a relatively shallow manner, with semantic competition occurring only when the target and competitor were previously mentioned together, perhaps by increasing the conceptual overlap between the target and competitor when in the same sentence, and reducing conceptual overlap when in a different sentence (see Altmann & Kamide, 2007, for a discussion). Given that the degree of semantic relatedness between the target and competitor was assessed using LSA (Landauer & Dumais, 1997) cosines, which are reliant upon the degree to which two words co-occur in a semantic space, it is possible that mentioning two semantically related objects in the same clause provides a further context by which these words co-occur in the immediate context of the discourse, transiently increasing the degree of perceived similarity amongst the two objects. Given that comprehenders are less likely to rely upon an event model when a protagonist is not included in a set of probes (Wilson et al., 1993), it is possible that because the discourse in the present experiment did not include a protagonist whatsoever, participants might be less likely to rely upon an event model during comprehension, instead only processing the discourse at the surface level (e.g. Kintsch, 1988; van Dijk & Kintsch, 1983); at which level similarity amongst the sentence/clause structure might be a salient feature. In order to address this concern, future experiments should manipulate the represented locations of the target and competitor (as well as distractors) within event models whilst controlling for the order of mention within each clause. Of note here is that this linguistic manipulation is crucial given that the present experiment shows that 'visual togetherness', or displaying a target and competitor in the same visual scene, does not act to negate any influence of ‘linguistic togetherness’ on semantic competition One way to implement this design improvement would be to use discourses such as the following, in Example 5.2:

Example 5.2. Example sentences to test the influence of event segmentation on semantic competition while controlling for any influence sentence structure

(1-2a) The lock is in the cafeteria, and the key is in the cafeteria. The ball is in the parlour, and the melon is in the parlour.

(1-2b) The ball is in the parlour, and the key is in the cafeteria. The lock is in the cafeteria, and the melon is in the parlour.

(1-2c) The key is in the parlour, and the lock is in the cafeteria. The melon is in the parlour, and the ball is in the cafeteria.

(1-2d) The melon is in the parlour, and the lock is in the cafeteria. The key is in the parlour, and the ball is in the cafeteria.

(3) It seems that the lock is very old.

In the above example, 1-2a and 1-2b both construct an event model in which the target (lock) and competitor (key) are maintained in the same location. While in both cases, the target and competitor are mentioned in separate clauses, in 1-2a, the two are mentioned in the same sentence, while in 1-2b the two are mentioned in separate sentences. As such, if competition between the target and competitor is driven by association with the same sentence, we should predict competition in item 1-2a, but not item 1-2b. However, if competition is driven by the event model, we should predict competition in both 1-2a and 1-2b. Similarly, items 1-2c and 1-2d both construct an event model in which the target and competitor are in separate locations; however the two objects are in the same sentence in 1-2c and in different sentences in 1-2d. In this case, if competition is driven by association with the same sentence, we should predict competition in 1-2c, but not 1-2d. However, if competition is driven by association with the same location, we should not expect any competition in either 1-2c or 1-2d. In this way, this experiment will confirm whether context in the form of an event model, or simple association with the same sentence, mediates semantic competition in the present experiment.

One further area of exploration, which was not possible to explore given the design of the materials in the present experiment, is the influence of switching focus from one working event model to another on the extent and time-course of semantic competition during discourse comprehension. As outlined in Section 5.1.1, comprehenders typically focus on the ‘here and now’ (Morrow et al., 1989), likely maintaining the most recently-mentioned location in working memory, thus foregrounding this location and the objects maintained within it. Using the items in Example 5.1 as a reference, the location mentioned in the second sentence is likely to be maintained in the working event model prior to the final sentence that refers back to the target object. If the target is in this foregrounded event model, on mention of the target comprehenders needn't switch focus from one event model to another. However, if the target is maintained in a different, backgrounded event model, attention must shift from the currently working event model to the one containing the target. Prior to this switch in attention, it is likely that information in the currently working event model is more highly accessible than information in the backgrounded event model that contains the target. If, indeed, this switch of focus from one event model to another occurs at a slower rate to the spread of activation in access for semantic competitors on mention of the target, i.e. at some point after 300ms after the mention for the target (Huettig & Altmann, 2005; Yee & Sedivy, 2006), we might predict strong but transient semantic competition in cases where the target and competitor are maintained in separate event models but the competitor is in the most recently mentioned event model (e.g. 1-2c in Example 5.1); that is, the competitor is likely to compete shortly after mention of the target, but not at all once the event model containing the target becomes foregrounded and the working event model containing the competitor becomes backgrounded. Similarly, we might predict earlier competition in cases in which the target and competitor are mentioned together in the most recently-mentioned event model when compared to cases where the target and competitor are mentioned together in the first-mentioned event model. Finally, if the target is mentioned in the most recent event model, but the competitor is mentioned in a previous event model, we should predict no competition at all on mention of the target.

As evidenced by the language used to outline the condition above, and their implications, in the present experiment, which event model is maintained in the foreground is intrinsically tied to which location/sentence was most recently mentioned. As such, any exploration into these predictions cannot distinguish between the influence of primacy/recency effects and differences in foregrounding/event switching on semantic competition. This is particularly problematic given that while facilitation of access for repeated words is relatively long-lasting, facilitation of access in semantic priming is relatively short (Dannenbring & Briand, 1982). Thus, as time goes on between the first and second mention of a target, the ease of access for the target and its semantically related objects decreases (see also Scarborough, Cortese, & Scarborough, 1977). To delineate any effect of recency of mention from accessibility for items in the currently working event model, future experiments must control for the recency of mention while manipulating which event model is currently maintained in working memory. One way to develop such materials would be to establish the location of a protagonist prior to mention of the critical sentence (Wilson et al., 1993), developing items such as those displayed in 3a and 3b in Example 5.3:

Example 5.3. Example sentences to test the influence of event structure on semantic competition while controlling for primary/recency of mention for the foregrounded/backgrounded locations

(1-2a) The lock and the key are in the cafeteria. The ball and the melon are in the parlour.

(1-2b) The ball and the melon are in the cafeteria. The lock and the key are in the parlour.

(1-2c) The lock and the melon are in the cafeteria. The ball and the key are in the parlour.

(1-2d) The ball and the key are in the cafeteria. The lock and the melon are in the parlour.

(3a) The boy sings in the cafeteria.

(3b) The boy sings in the parlour.

(4) And thinks that the lock is very old.

Because comprehenders typically focus on the protagonist of a narrative (Zwaan & Radvansky, 1998), and focus on the ‘here and now’ (Morrow et al., 1989), it is likely that reference to the location of a protagonist prior to the critical sentence would establish the event model to be foregrounded prior to the critical sentence (4). In doing so, it would be possible to establish whether any transient increase in semantic competition in 1-2c of Example 5.1 is affected by the location of the protagonist, and thus, which event model was recently foregrounded. In this case, if transient semantic competition is driven by which event model was initially foregrounded prior to mention of the target, and not on recent mention for the competitor, we should predict more competition in 3b when compared to 3a. Alternatively, if any transient semantic competition is driven by recency of mention alone, we should not predict any difference in the amount of competition exhibited in 1-2c following 3a or 3b. Similarly, this approach would also allow for an exploration into whether competition occurs in cases where the target and/or competitor are mentioned in the first sentence irrespective of which event model was most recently maintained in working memory.

Finally, while less crucial for confirming any influence of event model structure over the surface structure of language on accessibility for competitive sources of information, future experiments should address the sensitivity of different components of semantic information to contextual factors. While the present experiment showed that competition between semantically and/or associatively related objects can be manipulated by sentential context, recent research has shown that different components of semantic knowledge, such as perceptual (e.g. shape) and function information, are accessed at different timescales during language comprehension (Yee, Huffstetler, & Thompson-Schill, 2011). For example, given only a short 1 second preview of a visual display containing several objects, participants are more likely to fixate on a slice of pizza on hearing ‘Frisbee’ than upon hearing ‘thimble’ as the conceptual shape of the pizza, as a whole, shares a similar shape to the Frisbee. Given the same preview, there is no difference in the proportion of fixations on glue given either the conceptually related ‘tape’ or conceptually unrelated ‘cane’. However, given a 2 second preview of the visual display, both types of competition occur. Thus, perceptual information is typically accessible at a shorter timescale to conceptual information. Yee et al. argue that such results point to the organisation of perceptual knowledge in (or near) sensorimotor brain regions, requiring reactivation of sensorimotor traces of experience on access (see Barsalou, 1999, for a reivew), and the organisation of conceptual knowledge in brain regions associated with the integration of information from various sensory modalities. Hence, Yee et al. note that if the same neural substrates support both perceptual and conceptual activation, it is likely that viewing an object may directly and rapidly activate its shape, while accessing an object’s function may occur in an indirect and slower manner. Given this argument, an observation of whether event structure can modulate visual competition is intriguing given that two possible outcomes could occur: (1) If visual competition is relatively ‘low-level’ in comparison to function competition, and occurs on lexical access regardless of contextual appropriateness (e.g. Huettig & Altmann, 2007), we might predict that event structure cannot modulate visual competition; (2) Alternatively, if we observe that an event model is reliant upon views from mental images, isomorphic to what they represent, and reliant upon the same systems for perception as representation (Radvansky & Zacks, 2014), it is plausible that visual competition may be more sensitive to manipulations of event model structure than even that reported in the present experiment of this thesis. This raises a further line of enquiry; if we typically take the perspective of a protagonist during discourse processing, would removal of a visual competitor from the event model associated with a protagonist act to further decrease visual competition compared to cases in which no protagonist is introduced? That is, if the protagonist can't see a visual competitor, does the reader even consider the visual competitor? Research into such questions could potentially provide a rich avenue to establish the range of information that is influenced by linguistic context and by event model structure, as well as further establishing any differences in the activation and organisation of different types of semantic knowledge.

Aside from the potential avenues for further research implicated by the present experiment, the current findings are interesting in their own right given that they show semantic competition can be modulated by linguistic context. While it was predicted that, in line with the principles laid out by the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012), maintaining a target and semantically related competitor in the same event model would result in semantic competition on access for the target whereas maintaining the target and competitor in separate event models would reduce semantic competition in comparison, it was not predicted that maintaining the target and competitor in separate event models would entirely extinguish semantic competition on access. While such effects could be attributed to a manipulation of the conceptual overlap between the target and competitor through association with the same or separate sentences, rather than event models, it seems unlikely that associating the target and competitor with separate sentences would entirely remove any semantic competition on re-mention of the target; instead we might predict a decrease in competition only. As such, an interpretation based upon access for one event model over another, in which only the foregrounded event model (and information within it) is maintained in working memory, is more compatible with these results. Under this assumption, the present findings lend support to the notion that foregrounding improves accessibility of a target independently of any influence of a spatial shift (cf. Glenberg et al., 1987; Rinck & Bower, 1995; Rinck et al., 1997), and that event segmentation can act to improve accessibility for a target. Moreover, if the semantic competition can be modulated by event structure, in that maintaining a target and (different-object) competitor in a separate event model improves accessibility for the target, the present results provide evidence in support of event selection as the mechanism of competition outlined in Chapter 4 of the present thesis, given that maintaining a target and (same-object) competitor in separate event models reduced accessibility for the target in this case. However, given the caveats with the design of the present experiment, further research should attempt to establish the source of the context effects of semantic competition outlined here. The present experiment has shown that linguistic context can modulate semantic competition, but further research must establish whether this context is rooted in the sentential structure or event model structure within the narrative.

Chapter 6

Establishing the Role of Event Model Structure on Object-Accessibility in Discourse Processing

6.1. General Discussion

As much of human experience is centred on our understanding of events – guiding our perception, attention, memory, planning, and decision-making – an understanding of how we represent events is crucial for understanding general human cognition (Radvansky & Zacks, 2014). It is often assumed that in order to form an internal representation of a described state of affairs we must construct an event model (Radvansky, 2009), which acts as a mental simulation of events. This event model represents events along several dimensions such as space, time, causation, intentionality, and protagonist (Zwaan et al., 1995), with changes in the model along these indices associated with updating of the event model; a process itself associated with an increase in processing effort and a decrease in accessibility for information that shifts along any of these dimensions (Speer et al., 2007; Zwaan et al., 1995). While evidence indicates that event models are similar in structure regardless of the modality with which they are encoded (Glenberg et al., 1987; Radvansky & Zacks, 2014; Radvansky, 2009; van Dijk & Kintsch, 1983), this structure is necessarily an abstraction away from perceptual experience. As a consequence, recent research has been concerned with the extent to which event models are 'perceptual-like', addressing how the structure of an event model can influence accessibility for information maintained within. Given that event models formed from language, rather than experience, typically rely more upon schemata and inference in order to flesh out the event model, language as a modality provides a means by which to observe the necessary primitives required to form an event model, and a means to confirm the claim that event models are generally modality-independent regardless of whether they are constructed from language or reconstructed from physical experience. Understanding the spatial-temporal organisation of events is crucial to the basis of even the simplest event representation, but, between space and time, spatial information is often more restrictive and informative in defining an event than is time (Ehrlich & Johnson-Laird, 1982; Radvansky & Copeland, 2000; Radvansky & Zacks, 2014). Thus, in order to understand the structure of an event model it is necessary to understand how space is represented within it. The present thesis aimed to establish how space is represented in an event model, and the influence that the structure of the event model has on accessibility for information during discourse processing. Time, while important to the make-up of an event model, is beyond the scope of this thesis. Prior to establishing a detailed summary and explanation for the set of experiments in the present thesis in Section 6.1.2, Section

6.1.1 first provides a quick-reference to the series of experiments established within this thesis.

6.1.1. A Summary of the Series of Experiments Established in the present Thesis

The present set of experiments addressed how space is represented in discourse processing, aiming to establish how spatial representations can influence accessibility for information during online language comprehension. For reference, Table 6.1 contains a guide to the series of experiments, briefly outlining their aims and approaches, as well as the main observed findings of each experiment.

Table 6.1. A Summary of the series of experiments of the present thesis

Series of Experiments	Questions & Approaches	Interpretations
Euclidean vs. Categorical Distance		
Experiment 1 Concurrent visual world paradigm	Does Euclidean distance and/or categorical spatial shifts in a narrative reduce accessibility for a target?	No difference across conditions on access for the target.
Experiment 2 Blank-screen visual world paradigm	See above. Blank-screen paradigm used to remove visual-foregrounding.	Potential targets were less accessible during an anticipatory region following a categorical shift in space.
Shifts vs. Foregrounding		
Experiment 3 Concurrent quadrant display	Do spatial shifts and foregrounding individually contribute to accessibility for a target?	The target was more accessible when no shift occurred (particularly when the target was in the backgrounded model).
Instantiation Interference		
Experiment 4 Concurrent visual world paradigm	How is interference manifested when a moved object is associated with the same (Together) or different (Apart) event models?	The goal was less accessible, and the doorway more accessible, in the Apart condition (vs. the Together condition).
Experiment 5 Blank-screen visual world paradigm	See above. Blank-screen paradigm used to remove any low-level referential processing for fixations on the source location.	The source and goal were less accessible, and the doorway more accessible, in the Apart condition (vs. the Together condition).
Experiment 6 Concurrent visual world paradigm	Does boundary-type influence fixations on the doorway, source, and goal locations? Here, the source and goal were changed to containers to reduce effects of any low-level referential processing.	The source was more accessible with Line-type (vs. Doorway-type) boundaries. The source was less accessible in the Apart (vs. Together) condition with Doorway-type boundaries, but was more accessible for Line-type boundaries. Mixed findings on the goal by Togetherness. The goal and boundary were more accessible when using Doorway-type (vs. Line-type) boundaries. The boundary was also more accessible in the Apart (vs. Together) condition.
Semantic Competition		
Experiment 7 Concurrent quadrant display	Does association of a target and semantically-related competitor with the same (Together) or separate (Apart) event models modulate semantic competition?	The competitor was more accessible than the distractors in the Together condition, but not in the Apart condition. The target was more accessible, and competitor less accessible in the Apart condition (vs. the Together condition)

6.1.2. Overview of Experiments & Implications for Event Model Structure

Using language as a modality for encoding the event model provides a convenient means by which to manipulate the structure of an event model in ways that are relatively difficult with physical experience. For example, the effect of large shifts in space or time can be easily accommodated and analysed in language, but would be difficult to establish in a physical setting. Also, as an event model is often required in order to understand the sequence of events portrayed through language, an exploration into how events are represented in discourse comprehension is interesting in its own right. Thus, the present thesis addressed how space is represented in an event model, exploring how spatial categorisation and the spatial relations amongst entities within an event model can influence accessibility for information during discourse processing. In all experiments in the present thesis, a passive listening paradigm was employed such that an understanding of the structure of the event model could be obtained without any influence of task demands that might bias the spatial representation used (e.g. Rinck et al., 1997). Using eye-tracking afforded a means to test the accessibility of referents within the narrative without the need to employ an overt task. As such, the present thesis was concerned with how space is represented during relatively naturalistic contexts, and how this influences our ability to understand narrative events and access information within these representations. The present thesis set out with the aim to address three main points:

(1) Whether comprehenders build a spatial event model without the requirement for explicit instruction to do so.
(2) The time-course with which (any) event models influence accessibility for target objects.
(3) The metric of distance represented in event models that influences object accessibility in absence of an overt task (i.e. Euclidean vs. categorical).

6.1.2.1. Experiments 1 & 2

Experiments 1 and 2 were designed to address these points. In both experiments participants viewed a visual scene depicting a location containing five objects. In Experiment 1, the visual scene remained on-screen while a narrative played over speakers, whereas in Experiment 2 this visual scene was removed prior to the onset of the narrative. In both experiments, the narrative described a protagonist looking at two of the objects before carrying out an irrelevant action either in the initial location containing the two objects, or in a new (non-depicted) location close-to or far-away from the initial location. Thus, in both cases in which the protagonist moves to a new location a categorical shift in space has occurred but the distance between the initial and final location is either short or long. Following this sequence of events, the narrative described the protagonist thinking about one of the two objects initially mentioned in the first sentence. Accessibility for the object, in terms of the proportion of fixations on this object on mention, was compared across conditions. It was predicted that if comprehenders built an event model without an overt task, then differences in the accessibility for the object would reflect differences in the spatial framework used during comprehension. Further, it was predicted that if participants rely on a categorical representation of space, then the target would be less accessible on mention in the two shift conditions – which would not differ to one another – when compared to the no shift condition. If, however, participants rely on a Euclidean representation of space, then a gradient of accessibility was predicted; as the distance between the protagonist and the initial location increases, accessibility for the target would decrease.

In both Experiments, there was no difference in the proportion of fixations on the target throughout the entire time-window of the critical noun region in all conditions. However, in Experiment 2, during an anticipatory region prior to the onset of the critical noun, potential targets received a larger proportion of fixations in the no-shift condition than the shift conditions (which did not differ), suggesting that shifts in categorical distance, but not Euclidean distance, modulate accessibility for potential referents in discourse processing. However, the point at which the event model affected accessibility for information was earlier than expected, and was only manifested when using a blank-screen paradigm. This suggests that during passive listening tasks, comprehenders can and do use event models in discourse comprehension (cf. Zwaan & van Oostendorp, 1993), but are only likely to rely on an event model if it proves useful for comprehension. For example, in Experiment 1 and 2, it is possible that low-level referential processing guided fixations on the target on mention, resulting in participants fixating on the visual referent (i.e. Experiment 1) or where the visual referent was prior to the blank-screen (i.e. Experiment 2). In using a concurrent viewing paradigm in Experiment 1, it is likely that this effect could have been exacerbated when compared to using a blank-screen paradigm (i.e. Experiment 2). Moreover, it is possible that if the visual scene was present in the display this might have visually foregrounded the depicted location across all conditions. Thus, under these conditions, comprehenders are unlikely to rely on an event model in order to understand the narrative. However, removing the visual scene prior to the onset of the discourse (i.e. Experiment 2) is more likely to ensure that comprehenders rely on their event model to understand the unfolding narrative, causing anticipation of potential referents to be modulated by the spatial organisation of the event model in this case.

6.1.2.2. Experiment 3

While Experiment 2 established that a categorical representation of space is formed and relied upon when anticipating potential referents (if the event model is useful to the comprehender), it is not clear whether the higher level of accessibility for potential referents in cases where the protagonist stayed in the initial location reflects facilitation of accessibility for objects maintained in the working event model, or inhibition of accessibility for referents following a spatial shift – potentially due to costs associated with creating a new event model, and maintaining more than one event model in memory. While it is likely that both of these processes contributed to the observed effects, Experiment 3 aimed to explore whether the effects of foregrounding and spatial shifts could be observed in isolation.

In this experiment, a display containing four objects in each corner of a blank background replaced the visual scene; thus, no location mentioned within the following narrative was visually foregrounded. Using a concurrent viewing and listening paradigm, narratives described one character placing two of the objects in one location, and the other two objects in a different location. Following this, a protagonist was introduced; described as either moving to or from one location to another, or staying in one location (either containing the target object or not); manipulating whether a spatial shift occurred and whether the target was foregrounded, respectively. During the final sentence, 200ms after the onset of the critical noun, fixations on the target object were less likely following a spatial shift throughout the entire time-window, regardless of whether this occurred to or from the foregrounded event model. Moreover, the target was more accessible when no shift occurred, particularly when the target was in the backgrounded event model.

The results of Experiment 3 confirmed claims made by Event Segmentation Theory (Radvansky & Zacks, 2011) that a spatial shift can reduce accessibility for a referent independently of any effect of foregrounding, showing that updating an event model is cognitively demanding. However, of concern here was why a relatively robust finding in the narrative comprehension literature, that of foregrounding, was not observed. Several interpretations for this finding are discussed in Chapter 3. Of most concern here is that the introduction of multiple characters, and the mention of the assumed protagonist using possessives (e.g. ‘his sister’), may have interfered with comprehenders taking the perspective of the protagonist during comprehension, a factor crucial to observing any effect of foregrounding in the present design (Wilson et al., 1993). Combined with what appears to be clear effects of recency of mention, it is possible that confounds in the present design masked or impaired any influence of foregrounding on accessibility for the target. However, Chapter 5 raises another interpretation, that perhaps foregrounding, in the traditional interpretation (i.e. increased accessibility for a target in the working model), is difficult to detect using eye-tracking, given that on mention for a target attention must necessarily shift rapidly from the working model to that containing the target. Thus, Experiment 7 aimed to address the influence of foregrounding using an improved design. Still, the findings of Experiment 3 showed that a spatial shift is associated with reduced accessibility for a target regardless of foregrounding and/or recency of mention, supporting the argument following Experiments 1-2 that space is organised categorically during online language comprehension. Experiment 4-6 aimed to build upon Experiment 3, exploring how a spatial shift can influence the structure of event models, and specifically how association of an object with more than one event model causes interference on access for the object.

6.1.2.3. Experiments 4-6

Experiments 4-6 were designed to address the mechanism of interference during access for an object represented across multiple event models. In these experiments, a visual scene depicted two rooms, containing several objects, separated by a doorway. Narratives described a protagonist moving an object from one location to another (e.g. ‘The woman will take the book to the table.’). Crucially, this movement could involve crossing a doorway (i.e. from one room to another; Apart condition), or not (i.e. within one room; Together condition), such that according to Event Segmentation Theory (Radvansky & Zacks, 2011; Zacks et al., 2009) and the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) the two instantiations of the book were represented across separate event models, or in one event model, respectively. Crucially, these experiments were concerned with how interference is manifested on access for an object associated with more than one event model; an undefined mechanism in the Event Horizon model. Based on the assumption that comprehenders attempt to select the relevant model from irrelevant models, and suppress irrelevant models on access for the final instantiation of the object, three likely outcomes were outlined (amongst others). These predictions outline a mechanism of competition prior to accessing a goal, as in (i) and (ii), and a mechanism of interference from the irrelevant model when accessing the final instantiation of the object, as in (iii):

(i) A decrease in accessibility for the final instantiation of the book (henceforth, goal), with little change in accessibility for the initial instantiation of the book (henceforth, source)

(ii) A decrease in accessibility for both instantiations of the object.

(iii) A decrease in accessibility for the goal due to an increase in accessibility for the source, driven by dissimilarity-based competition (Hindy et al., 2012).

6.1.2.3.1. Experiment 4

Experiment 4 aimed to address the mechanism of interference using the method outlined above. In this experiment, a concurrent viewing paradigm was used. Focusing on accessibility for the source, goal, and boundary across conditions as reflected by the proportion of fixations on these locations throughout the entire time-window, on hearing the critical noun (i.e. ‘book’, during ‘Then she will study the picture and pick up the book.’), there was no difference in accessibility for the source across conditions, but the goal was less accessible when the source and goal were maintained in two separate event models (henceforth, Apart condition) than when they were maintained in one event model (henceforth, Together condition). While these findings could be taken in support of prediction (i), further analyses revealed that the boundary between the goal and source was more accessible in the Apart condition than the Together condition. Chapter 4 discusses several possibilities for the larger proportion of fixations on the boundary in the Apart condition (vs. the Together condition), but briefly, fixations here could reflect a central fixation bias (Tatler, 2007), supporting (i); misallocated fixations intended for the source (Driver & Baylis, 1989; Eriksen & Eriksen, 1974), supporting (iii); or differences in visual saliency (see Fecteau & Munoz, 2006; Parkhurst, Law, & Niebur, 2002), or differences in the simulated events, reducing accessibility for the source and goal (Coll-Florit & Gennari, 2011; Kamide et al., 2015), thus failing to support any interpretation of interference outlined above. Finally, in using the concurrent viewing paradigm, it is likely that fixations on the source could be driven by low-level referential processing (i.e. looking at the book upon hearing ‘book’), such that the source differs in accessibility across conditions but was not detected in the above paradigm, in which case it is impossible to distinguish between predictions (i), (ii), and (iii) from the present findings. Experiment 5 thus used an improved paradigm to distinguish between these interpretations.

6.1.2.3.2. Experiment 5

Experiment 5 used the same design as Experiment 4 but employed the blank-screen paradigm (e.g. Altmann, 2004) in order to reduce the potential confounds associated with differences in the visual scene when processing the narrative. Focusing on accessibility for the source, goal, and boundary across conditions as reflected by the proportion of fixations on these locations throughout the entire time-window, on hearing the critical noun (i.e. ‘book’, during ‘Then she will study the picture and pick up the book.’), the source and goal were more accessible in the Together condition than the Apart condition. Also, the boundary was more accessible in the Apart condition than the Together condition. Such a finding is consistent with prediction (ii), that both instantiations of the object are less accessible in the Apart condition due to the need to select the relevant event model from the irrelevant event model (and thus, suppress the irrelevant event model). While seemingly also consistent with the claim that both instantiations of the object are more accessible when in the working event model, such an interpretation is inconsistent with the prior literature showing that as the number of event models associated with a goal increases, accessibility for the goal decreases (Radvansky, 1999). Again, however, caution must be applied when interpreting the findings of Experiment 5. It is possible that, rather than driven by low-level visual features, the boundary received a larger proportion of fixations in the Apart condition (vs. Together condition) due to comprehenders simulating a more complex sequence of events (Coll-Florit & Gennari, 2011) (i.e. opening up and walking through the doorway). While this effect would likely be isolated to a lower proportion of fixations on the goal only, it is possible that representing such events earlier in the narrative was more complex or cognitively demanding, slowing word recognition (see Experiment 6 in Baddeley et al., 1984) and/or reducing accessibility for either instantiation of the object. Experiment 6 thus aimed to explore whether the same effects reported above could be found when using both Doorway-type and Line-type boundaries in order to explore the contribution of boundary size and the estimated duration/complexity of events across conditions.

6.1.2.3.3. Experiment 6

Experiment 6 compared differences in the fixation behaviour across conditions using similar items to Experiments 4 and 5. However, half of the items used the similar, large, Doorway-type boundaries and half used smaller, Line-type boundaries. This change was implemented to address differences in fixation behaviour driven by the visual saliency of the boundary and/or the influence of the boundary on the simulated complexity of events. In order to ensure that differences in the boundary were noticed and relied upon during comprehension, a concurrent paradigm was reinstated; to ensure that fixations on the source and goal were driven by the mental representations of the object, and not on low-level referential processing, the narrative described (and depicted) two containers that the (unseen) object moved between. Focusing on accessibility for the source, goal, and boundary across conditions as reflected by the proportion of fixations on these locations throughout the entire time-window, on hearing the critical noun (i.e. ‘book’, during ‘Then she will study the picture and pick up the book.’), when collapsing across Boundary-type the source was more accessible in the Together condition (vs. the Apart condition), and when using Line-type boundaries (vs. Doorway-type boundaries). An interaction was also found between these factors in which the source was more accessible in the Together condition only when using Doorway-type boundaries (with the opposite effect for Line-type boundaries). Such findings suggest that perhaps the presence of a large division between locations is necessary to construct two event models in the Apart condition, such that event competition only occurs when using Doorway-type (vs. Line-type boundary items). Moreover, the results for the target were rather mixed, with significant differences in fixations here in opposite directions for the by-participants and by-items analyses, potentially due to a failure to orthogonally manipulate these two factors within items. Yet, the goal was more accessible across conditions when using Doorway-type boundaries (vs. Line-type boundaries). Finally, the boundary was more accessible in the Apart condition (vs. the Together condition), and when using Doorway-type boundaries (vs. Line-type boundaries). While the two factors interacted for fixations on the source, there was no reliable interaction for the goal and boundary across the by-items and by-participants analyses, suggesting that for these locations the effects of Togetherness and Boundary-type were independent of one another. This suggests that visual while visual saliency (see Fecteau & Munoz, 2006; Parkhurst et al., 2002) and/or simulating a more complex sequence of events (Coll-Florit & Gennari, 2011) could contribute to the proportion of fixations on the boundary and/or target, they are unlikely to be the only factor at play.

6.1.2.3.4. Conclusions from Experiments 4-6

One confound with Experiment 6, aside from the failure to manipulate the two factors within items, is that the discourse was highly predictable throughout the experiment due to a failure to include any filler items (cf. Experiments 4 and 5), such that fixations on the goal driven by the event model structure may have been masked by comprehenders anticipating mention of the goal-associated target prior to mention. As such, while Experiment 6 offered an avenue for exploring the locus of effects reported in Experiments 4 and 5, due to drawbacks in its design, conclusions about the mechanism of interference must rely on a consideration of the evidence from all three experiments, bringing potential confounds into consideration.

Experiment 5 was largely robust to a range of confounds associated with Experiments 4 and 6. Here, both the source and goal were less accessible, and the boundary more accessible, in the Apart condition when compared to the Together condition. Similar findings were reported for the goal and boundary in Experiment 4, however, the proportion of fixations on the source was equivalent across conditions, likely driven by low-level referential processing potentially masking any differences in accessibility for the competitor across conditions. In Experiment 6, while rather inconclusive findings were reported for the goal, in line with Experiment 5, the source was less accessible (at least for Doorway-type boundary items), and the boundary more accessible, in the Apart condition. Thus, taken together, the most reliable findings across Experiments 4-6 is that both the source and goal are less accessible, and the boundary more accessible, in the Apart condition when compared to the Together condition. When using a blank-screen paradigm (i.e. Experiment 5) fixations on the boundary are unlikely to be driven by the features of the visual scene. Moreover, given that in Experiments 4-6, the boundary was located centrally between the source and goal in the Apart condition, but not in the Together condition, it is likely that the larger proportion of fixations here in the Apart (vs. Together) condition is driven by either a central fixation bias (Tatler, 2007), or a tendency to fixate on a point located centrally between the source and goal while attempting to access the target. As such, the trade-off in fixations on the boundary at a cost to fixations on both the source and goal in the Apart (vs. Together) condition is likely a by-product of a difficulty associated with resolving which event model (and instantiation of the target) to access. This conclusion fits with prediction (ii), that interference occurs on access for an object represented across multiple event models due to the need to select between two event models; accessing the relevant model, and suppressing the irrelevant model. This event selection process is manifested in a reduced accessibility for both instantiations of the object, likely attributed to increased cognitive load reducing or slowing access for the relevant event model (and instantiation of the object), and the active suppression of the irrelevant event model (and instantiation of the object). The implications of these findings are discussed further in Section 6.1.4, which outlines how this event selection process might work; thus, aiming to expand on the principles of the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012).

6.1.2.4. Experiment 7

Section 6.1.2.2 highlighted the failure of Experiment 3 to reproduce any effect of foregrounding; an established effect in the narrative comprehension literature. However, as outlined in Chapter 5 (and further in Section 6.1.2.2), it is possible that any influence of foregrounding on accessibility for a target is difficult to detect using eye-tracking. There are two main reasons why foregrounding, in terms of greater accessibility for a target object, may be difficult to detect in Experiment 3. Firstly, on mention for a target, if the target is depicted in the visual scene, it is likely that low-level referential processing (i.e. looking at the target on mention) guides visual attention. This could mask any bias in terms of accessibility for a target when in the foregrounded (vs. backgrounded) event model. Secondly, if the target is in a backgrounded event model it is likely that on mention for the target this prompts a shift in attention from the working event model to the backgrounded event model containing the target. Thus, any difference in accessibility for the target between the foregrounded and backgrounded cases reflects the time taken to switch focus from one event model to another, rather than a sustained difference in the accessibility for information in a working vs. a backgrounded event model.

In order to address these issues, Experiment 7 presented participants with a quadrant containing a target (e.g. lock), a semantically-related competitor (e.g. key), and two unrelated distractors (e.g. ball, melon). Participants viewed this quadrant while concurrently listening to a narrative describing the objects in pairs in one of two locations before mentioning the target in a final sentence. Crucially, in the narrative, the target and competitor could be described in the same (Together condition) or different (Apart condition) locations. Thus, on mention for the target, the competitor could be in the same (foregrounded) event model as the target, or not, respectively. Here, it was predicted that on mention for the target later in the discourse semantic competition would be strongest in the Together condition when compared to the Apart condition. Two-hundred milliseconds after the onset until 200ms after the offset the target (e.g. ‘lock’), semantic competition – in terms of a larger proportion of fixations on the competitor than the average of the two distractors – was found as time went on in the Together condition but not in the Apart condition. These effects occurred in the same direction 300ms after the onset of the critical noun (‘lock’) until the offset of a spillover region (‘is’) throughout the entire time-window (i.e. on the intercept). In both regions, participants were less likely to fixate on the target and more likely to fixate on the competitor throughout the entire time-window if the target and competitor were in the same (foregrounded) event model (i.e. in the Together condition) than if the competitor was maintained in a different (backgrounded) event model (i.e. in the Apart condition), showing that semantic competition is modulated by sentential context, and that foregrounding biases accessibility for competitive sources of information in discourse processing. While it is possible that the current findings are driven by association of the target and competitor with the same/separate sentences rather than by association with the same/separate event models, future studies should aim to orthogonally manipulate these two factors. However, given the body of evidence so far discussed in the present thesis, the notion that event model structure can modulate competition is promising.

6.1.3. Conclusions and Implications of the Series of Experiments

Across the series of experiments, spatial representations have been found to influence accessibility for information in discourse processing. Experiment 2 showed that comprehenders can build an event model without explicit instruction to do so, such that under passive listening tasks a shift in categorical space reduced accessibility for potential referents. What was not clear from the results of Experiment 2, however, was whether a spatial shift reduced accessibility for potential referents, or whether potential referents were more accessible when in the foregrounded event model when no shift has occurred. Experiment 3 aimed to orthogonally manipulate these two factors (foregrounding and spatial shifts) to isolate the effects reported in Experiment 2. While no effects of foregrounding were found here, it is likely that this was driven by comprehenders failing to take the perspective of the protagonist within the narrative. Of note, however, was that a spatial shift reduced accessibility for the target on mention, presumably due to processing costs associated with updating the event model. Together, these experiments established that comprehenders can build and use an event model based around categorical locations (rather than Euclidean distance), and that updating an event model following a spatial shift is associated with reduced accessibility for potential targets (i.e. Experiment 2), and targets (i.e. Experiment 3) during comprehension. While Experiment 3 failed to find any effect of foregrounding, it is likely that the design of this experiment precluded any detection of this widely established effect in the literature (see Section 6.1.2.2 for a detailed discussion) (e.g. Glenberg et al., 1987). Indeed, using an improved paradigm, Experiment 7 found that association of a target and semantically-related competitor with different (vs. the same) event models reduced accessibility for the competitor, and thus removed any effect of semantic competition when accessing the target. Thus, in this case, foregrounding likely influenced accessibility for information maintained within the event model on access, modulating competition on access for the target.

Experiments 4-6 aimed to establish the mechanism of interference associated with maintaining two instantiations of a target object in separate event models (i.e. the Apart condition) (vs. the same event model (i.e. the Together condition)). While Experiment 4 showed that association of the target with separate event models reduced accessibility for the final instantiation of the target (i.e. the goal) – but not the initial instantiation (i.e. the source) – it is possible that the lack of any difference in accessibility for the source was driven by low-level referential processing associated with looking at the object in its initial location on mention. Moreover, a reduction in accessibility for the goal when the two instantiations of the object was associated with separate event models may have been influenced by the boundary between the two locations attracting more attention in this condition. To remedy these issues, Experiment 5 used a blank-screen paradigm, rather than the concurrent viewing paradigm used in Experiment 4. Here, accessibility for the source and goal was reduced when the object was associated with separate event models. However, again, the doorway attracted more attention in this condition, potentially due to the need to simulate a more complex (or longer lasting) sequence of events (e.g. opening and passing through the doorway) in this condition (cf. Coll-Florit & Gennari, 2011). Experiment 6 aimed to address whether the type of doorway influenced accessibility for the source and goal locations, exploring whether a simple Line-type boundary – which would not impede the motion of the protagonist – would show similar findings to the Doorway-type boundaries used in Experiments 4 and 5. While the source was less accessible (at least in Doorway-type boundary items) and the boundary more accessible when the two instantiations of the object were associated with separate event models (vs. the same model), no interaction was found between Boundary-type and condition in regards to the proportion of fixations on the boundary (on the intercept term), suggesting that the reported effects in Experiments 4 and 5 cannot be attributed solely to the presence of a large visually-distracting and obstructing (in terms of simulated movement) boundary between the path of movement of the protagonist. Experiment 6, however, suffered from confounds associated with a high-degree of predictability within the discourse. Returning to the most well designed experiment in this series of experiments, Experiment 5, it seems likely that reduced accessibility for the source and goal is driven by the need to maintain and select between multiple relevant event models on access for the target. As such, interference on access for the target is likely driven by this event selection mechanism, which is established in more detail in Section 6.1.4.

Together, the series of experiments in this thesis have established:

(a) Comprehenders can build and use event models when necessary for comprehension, and do so when anticipating potential referents, and when accessing a referent.

(b) Event models rely on a categorical representation of space during passive listening tasks.

(c) Spatial shifts which induce the updating of an event model result in reduced accessibility for a target.
(d) Information maintained in the foregrounded event model is more accessible than information maintained in a backgrounded event model.
(e) When information is represented in more than one event model, interference occurs likely due to the need to maintain and select between multiple relevant event models.

These findings inform a model for how information is accessed within an event model during narrative comprehension. Section 6.1.4 will outline this model, building upon the principles laid out by the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) and Event Segmentation Theory (Radvansky & Zacks, 2011) to outline a mechanism for how and when an event model is accessed, and the effect this has on accessibility for information maintained within a given event model.

6.1.4. Towards an Understanding of Event Model Access

The Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) outlines five main principles for how event boundaries influence the accessibility of information maintained within an event model. Firstly, sequences of events are separated into different event models at event boundaries, or points of change in the sequences of events at which the working event model can no longer accurately predict upcoming events; an example of which is a large shift in space or time (e.g. walking through a doorway). Secondly, comprehenders construct a causal network of the sequence of events in order to improve understanding and memory for unfolding events. Thirdly, information in the working (foregrounded) event model is most accessible. Fourthly, information that is maintained across multiple event models is more accessible during non-competitive retrieval. Fifthly, retrieval interference occurs when information is maintained across multiple event models during competitive retrieval.

The first claim was confirmed in Experiments 2 and 3 of the present thesis, in that crossing an event boundary was associated with reduced accessibility for potential targets and for the target respectively. Later experiments built upon this notion to establish further effects outlined in the Event Horizon model, exploring the third (Experiment 7) and fifth principles directly (Experiments 4-6), while also indirectly establishing how the fourth principle can contribute to accessibility for information (Experiment 7). Importantly, Experiments 4-6 established a potential mechanism of interference associated with competitive retrieval, expanding on the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) by outlining not just when interference occurs, but how, and why. Indeed, while the principles outlined by the Event Horizon model are useful in establishing the conditions with which an effect might occur, beyond the effects of foregrounding this model provides no detailed explanation for the processes involved in accessing information within an event model, and how these processes differ under the conditions established above. Thus, in order to explain why the above effects occur it is necessary to outline a general mechanism for how event models and the information maintained within them are stored, and how information is accessed from within an event model; outlining how the different conditions can influence the processes involved in accessing information within an event model. This section will outline the processes involved in accessing information within an event model across the series of experiments in the present thesis, establishing how the observed effects occur, and the implications this has for the organisation of event models in memory.

When using an event model to understand a narrative, we often foreground the location containing the protagonist (Glenberg et al., 1987) or the most recently mentioned location (e.g. Experiment 3 of the present thesis). Prior to mention for information (e.g. an object) associated with any event model, information in the foregrounded model is more accessible than information maintained outside of this event model. Thus, on mention for an object, this object is relatively easy to access if in the foregrounded event model. But, if the object is in a backgrounded event model this necessitates a switch of attention; flushing the working event model from working memory and bringing a backgrounded event model from long term memory into working memory in order to access the object (Radvansky & Zacks, 2011). This 'event switching' process is associated with an increase in processing effort and time taken to access the backgrounded event model, making access for the object relatively more difficult than if the object was in an initially foregrounded event model. This process was established in Experiment 2, in line with findings in the literature exploring the effects of foregrounding (e.g. Glenberg et al., 1987), and is portrayed in Figure 6.1 below.

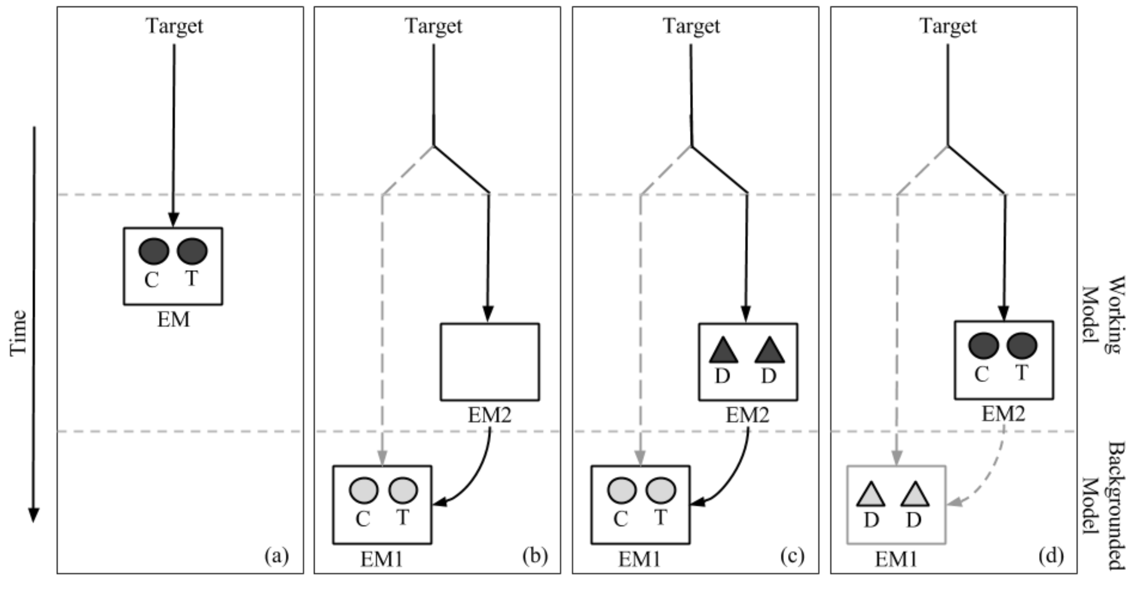


Figure 6.1. Experiments 1-2: A process of event model access where (a) only one event (EM) model is maintained, with a target (T) and competitor (C) in the same foregrounded event model; (b) two event models are maintained (EM1 & EM2) with the target and competitor in a backgrounded event model, but no objects are maintained in the working event model; (c) two event models are maintained with the target and competitor in a backgrounded event model, with distractors (D) in the working event model; (d) two event models are maintained with the target and competitor in the foregrounded event model, with distractors maintained in a backgrounded event model

In all figures, accessibility for information (e.g. an object) is indicated by the level of shading for objects, with highly accessible objects depicted in a dark pigment, and less accessible objects depicted in a light pigment. The route to accessing information from an event model is depicted by dark arrows; less preferred routes to access or potential routes to accessing information are depicted by lightly pigmented, broken arrows. Switching focus from one event model to another is indicated by a curved arrow. Whether or not this switching occurs is dependent upon whether or not the target is in the model that requires a switch of focus. If so, this arrow is dark in pigment (as depicted in panel (b)) and if not, it is light in pigment (as depicted in panel (d)). In all figures, if two event models are present, EM2 depicts the most recently mentioned event model, or the event model associated with the current location of the protagonist. As such, EM2 is typically foregrounded prior to mention of the target.

Figure 6.1 depicts Experiments 1 and 2 in the present thesis. Panel (a) depicts the No-shift condition in Experiments 1 and 2, in which the protagonist does not move from the initial location prior to mention for the target. Panel (b) depicts the Shift conditions, in which a categorical spatial shift was made from one location to another. In Experiment 2, potential targets were more accessible in (a) than in (b), supporting the models outlined in panels (a) and (b) above. Panels (c) and (d) represent theoretical possibilities based on the observed data from Experiment 2 and the wider event cognition literature, and were not tested in Experiments 1 and 2. When the protagonist stays in the initial location containing the target, only one event model is maintained, and this model is held in working memory (e.g. panel (a)). Here, access for the target is relatively straight-forward, involving accessing the target from the model in working memory. However, when the protagonist shifts to a new location, the new location is foregrounded, and the event model containing the target and competitor is backgrounded (e.g. panel (b)). In this case, accessing the target involves switching focus from the foregrounded event model and accessing the backgrounded event model containing the target, a more cognitively demanding process than that outlined in panel (a). Panels (c) and (d) represent cases in which other sources of information are introduced in the event models. Panel (c) introduces distractors in the working event model. The processes involved in accessing the target from the backgrounded event model should be similar in panels (b) and (c), as research indicates that introducing more information in a location does not increase response times for accessing a target; only increasing the number of locations associated with an object increases response times (Radvansky & Zacks, 1991). While panel (d) portrays the target and competitor in the working event model, accessibility should be reduced compared to panel (a) – in which only one event model is held in mind – due to the need to maintain more than one event model and/or to suppress the irrelevant event model. While panels (a) and (b) are based on observed data from Experiments 1 and 2, panels (c) and (d) are based on inferences drawn from the body of work in the event model literature. In all cases, the consistent process is the preferred access for the working event model prior to switching focus to the event model containing the target (if necessary). Figure 6.1 therefore shows how foregrounding and event switching costs influence accessibility for the target, and how maintaining more than one event model can influence the rate of access for information in a foregrounded or backgrounded event model.

Once focus has switched from the initial event model to the model containing the target, the model containing the target becomes foregrounded, with information in the now foregrounded event model becoming more accessible than information in other event models. This effect was shown in Experiment 7, in which access for a semantic competitor was mediated by whether or not it was contained in the event model associated with the target. An interpretation of the mechanisms at play in Experiment 7 is depicted in Figure 6.2, below.

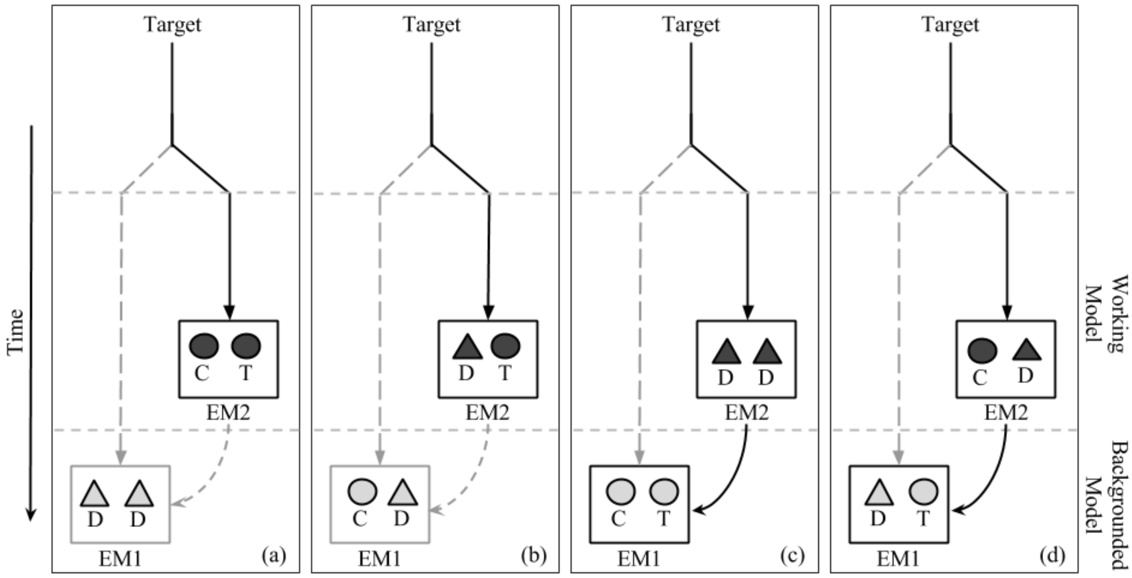


Figure 6.2. Experiment 7: A process of event model access where (a) two event models (EM1 & EM2) are maintained, with the target (T) and semantically-related competitor (C) in the foregrounded event model (EM2), and two distractors (D) maintained in a backgrounded event model (EM1); (b) two event models are maintained with the target and a distractor in the foregrounded event model, and the semantically-related competitor and a distractor in the backgrounded event model; (c) two event models are maintained with two distractors in the foregrounded event model, and the target and semantically-related competitor in the backgrounded event model; (d) two event models are maintained with the semantically-related competitor and a distractor in the foregrounded event model, and the target and a distractor in the backgrounded event model

Panels (a) and (c) of Figure 6.2 represent the Together conditions in Experiment 7, in which the target and competitor were associated with the same event model. In panel (a), this event model is initially foregrounded, whereas in panel (c), this event model is initially backgrounded. In Experiment 7, the Together condition collapsed across both cases presented in panels (a) and (c), and the influence of holding the target in the foregrounded/backgrounded event model prior to access for the target was not addressed. Interpretations of the differences in panels (a) and (c) are thus based on theoretical assumptions from the observed data and prior work on foregrounding (e.g. Glenberg et al., 1987). In both cases, because the competitor is a different object to the target it is equally accessible as the target and any other object prior to accessing the target and it is not suppressed when any event model is accessed. This is in contrast to cases in which the target and competitor are two instantiations of the same object (e.g. in Experiments 4-6) (see also Radvansky, 2012). In both panel (a) and panel (c) in Figure 6.2, the event model containing the target is accessed on mention for the critical noun (i.e. the target), with information in the event model containing the target becoming highly accessible if it was not already foregrounded (i.e. panel (c)). In such cases, the competitor is highly accessible because it is initially held and maintained in the foreground (i.e. panel (a)) or becomes held in the foreground (i.e. panel (c)) on mention for the target; a finding supported by Experiment 7. However, given the principles outlined in Figure 6.1 and reported in Experiment 2, information in the most recently mentioned event model (i.e. the model initially held in working memory) should initially be more accessible than information maintained in backgrounded event models. Thus, while not explicitly tested in Experiment 7, access for the target and competitor should take longer in panel (c) than in panel (a), due to the need to switch focus from the initially foregrounded event model to the initially backgrounded event model in order to access the target.

On the other hand, panels (b) and (d) of Figure 6.2 represent the Apart conditions in Experiment 7, in which the target and competitor were associated with separate event models. In Experiment 7, the Apart condition collapsed across both panels (b) and (d) and observed no semantic competition. However, if the most recently-mentioned event model is foregrounded prior to mention, we might predict different effects from panels (b) and (d). In panel (b), the target is in the foregrounded event model, and as such, only this event model is accessed, with information in the backgrounded event model – including the semantically-related competitor – at a lower level of accessibility. In this case, there is no need to switch focus from the initially foregrounded event model to the event model containing the competitor, and as such the competitor does not compete on access for the target. However, in panel (d) it is likely that on mention for the target, the semantically-related competitor is transiently highly accessible because it was maintained in the most recently-mentioned (and initially foregrounded) event model. But, once attention shifts to the event model containing the target, the initially foregrounded event model becomes backgrounded, reducing accessibility for the competitor and increasing accessibility for the target. Once this shift in attention has occurred, it is likely that no semantic competition occurs. While Experiment 7 collapsed across the four cases to analyse only the effect of maintaining the target and competitor in the same or separate event models to control for recency of mention, these predictions about differences within the conditions follow from the observed data for foregrounding in Experiment 2 and from the model of foregrounding effects outlined in Figure 6.1. In all cases here, the rate of access for the foregrounded and backgrounded event model is equivalent as comprehenders represent the same number of event models across conditions. Figure 6.2 thus outlines how association of the target and competitor with the same or separate event models can modulate the effect of competition exhibited on access for the target.

Together, the processes outlined in Figure 6.1 and Figure 6.2 show how information in an initially foregrounded event model is more accessible than information in a backgrounded event model prior to accessing the target. Figure 6.1 shows that once a protagonist makes a shift from one location to another a new event model must be created and maintained. The consequence of the need to represent more than one event model due to the protagonist making a shift to a new location is reduced accessibility for information in the foregrounded and backgrounded event models due to an increase in processing load. Both Figure 6.1 and Figure 6.2 show that accessing information from a backgrounded event model is more costly than accessing information from a foregrounded event model. In this case, a switch of focus must occur in which the backgrounded event model is retrieved (presumably from long term memory), causing reduced accessibility for the target when compared to cases in which it is maintained in the foregrounded event model (presumably held in working memory). Figure 6.2 shows that, once accessed, information in the same event model as the target becomes more accessible as this model becomes foregrounded, while other event models (even if relevant prior to access) become backgrounded and thus less accessible; once accessed, only information maintained in the accessed event model is more accessible through foregrounding, while other, irrelevant event models are relegated to the background. However, these processes cannot account for the lack of a foregrounding effect in Experiment 3, or for the cost to a spatial shift here.

In Experiment 3, comprehenders were initially introduced to both locations in the narrative, and thus presumably maintained and represented two event models for both locations. In this experiment, there was a main effect of spatial shifts, in which the target was less accessible if a spatial shift was made (vs. not made). However, Experiment 3 failed to find any main effect of foregrounding that might have been predicted from the prior literature (e.g. Glenberg et al., 1987). An interaction between these two factors was found, in which the target was more accessible if no spatial shift was made and the target was in the backgrounded event model, however this finding – particularly the influence of foregrounding – can be attributed to an imbalance in the recency of mention for the location containing the target across the two No-shift conditions. However, even if a spatial shift occurred in the narrative, we should expect to see an influence of foregrounding, in which the target if more accessible if a spatial shift is made to the location containing the target (vs. from the location containing the target), however this was not found. Due to various reasons such as confusion amongst which character in the narrative was the protagonist, taking the perspective of the first-mentioned character (in an indeterminate location), or through introducing both locations immediately prior to mention for the target, it is possible that comprehenders maintained both event models at a similar level of accessibility prior to mention; either in long term memory or in working memory. The Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) assumes that only one event model can be maintained in working memory. Under this assumption, Figure 6.3 depicts both event models in the Shift condition at a similar level of accessibility, both as backgrounded models. In Figure 6.3, the present location of the protagonist is always the second model in the diagram; EM2. While typically EM2 would be the working (foregrounded) event model and EM1 would depict the backgrounded event model (as in Figure 6.1 and Figure 6.2), in Experiment 3 no main effect of foregrounding was reported such that both models are held at a similar level of accessibility in the Shift condition. Moreover, in the No-shift conditions, because the target was less accessible when in the same location as the protagonist (i.e. EM2) and more accessible when in a different location to the protagonist (i.e. EM1), EM1 is the working model, and EM2 is the backgrounded model. Thus, while in all panels EM1 represents the model that was initially assumed to be backgrounded, and EM2 represents the model that was initially assumed to be foregrounded (i.e. due to the location of the protagonist), in the Shift conditions no model is foregrounded, and in the No-shift conditions the labels for foregrounding are essentially reversed; because the location containing the protagonist (i.e. EM2) was always mentioned first in the narrative and the location not containing the protagonist was always mentioned last in the narrative, the last mentioned event model (i.e. EM1) – rather than the location of the protagonist – was likely to be foregrounded in all cases.

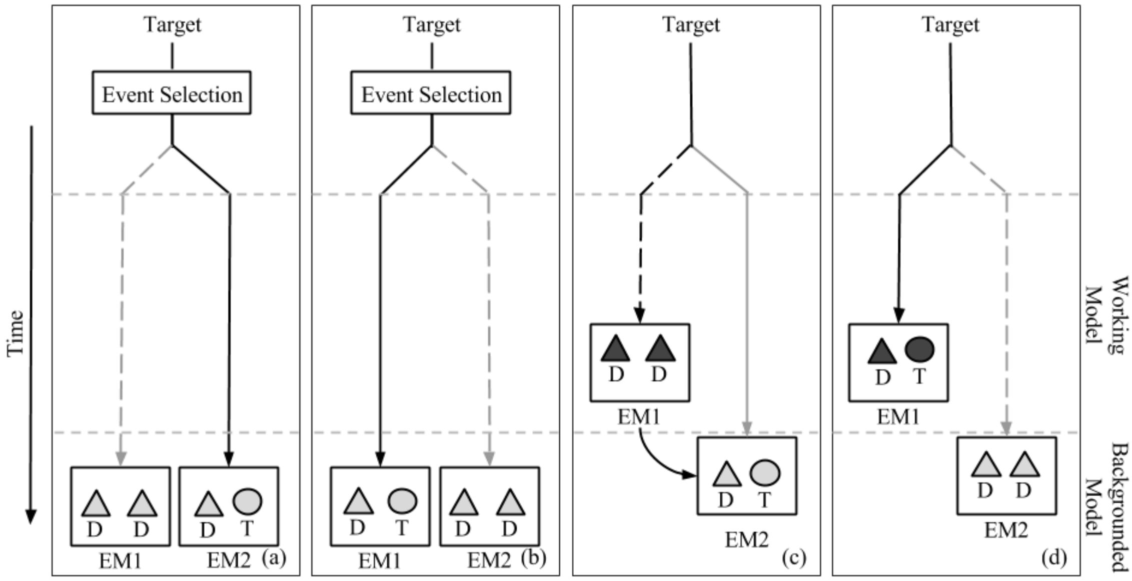


Figure 6.3. Experiment 3: A process of event model access where (a) two event models (EM1 & EM2) are maintained at a similar level of accessibility following a spatial shift, with the target (T) in the same event model as the protagonist (i.e. EM2); (b) two event models are maintained at a similar level of accessibility following a spatial shift, with the target in a different event model to the protagonist (i.e. EM1); (c) the event model containing the target and protagonist (EM2) is maintained at a lower level of accessibility than the most recently mentioned event model following no spatial shift; (d) the event model containing the target (EM1) is maintained at a higher level of accessibility than the event model containing the protagonist (EM2) following no spatial shift. In all panels (D) represents distractor objects

In Figure 6.3, panels (a) and (b) depict the Shift and foregrounded condition and the Shift and backgrounded condition respectively, and panels (c) and (d) depict the No-shift and foregrounded condition and the No-shift and backgrounded condition respectively. In panels (a) and (b) a spatial shift occurred in the narrative prior to mention of the target. In such cases, the event models must be updated to accommodate the change in location for the protagonist. This updating process is thought be cognitively demanding (Radvansky & Zacks, 2011) associated with a decrease in accessibility for the target. As such, panels (a) and (b) depict the accessibility for both models at a lower level than the models in panels (c) and (d) due to the increased processing costs associated with representing a spatial shift. While both models in panels (c) and (d) are more accessible than those in (a) and (b), here the most recently-mentioned event model is more accessible than the first-mentioned event model. Thus, in panel (c) the event model containing the protagonist is initially backgrounded, and a switch of focus from one event model to another is required in order to access the event model containing the target. This process is more costly than that depicted in panel (d), which shows that the most recently-mentioned event model is initially foregrounded prior to mention for the target, and on mention for the target, no switch in focus from one event model to another is required, such that the target is more accessible in (d) than (c). Collapsing across panels (a) and (b) for the conditions in which a shift occurred, and across panels (c) and (d) in which no shift occurred, it is clear that a spatial shift reduces accessibility for the target. However, it must be noted that the lack of a foregrounding effect based on the location of the protagonist was not expected here. As such, the model outlined in Figure 6.3 depicts the observed data, rather than the predicted data. If comprehenders took the perspective of the protagonist when processing the narrative, the predicted process would have been more in line with panels (a) and (c) from Figure 6.2, which show that there is a general cost to accessing information in a backgrounded event model. Here, the only predicted difference would have been a shift in the time taken to access the foregrounded and/or backgrounded event models if a spatial shift occurred when compared to cases when no spatial shift occurred.

In panels (a) and (b) in Figure 6.3, while the darker line shows the route to accessing the target from the correct event model, if access for the correct event model continues in a serial fashion, as outlined by the darker lines in Figure 6.1 and Figure 6.2, then an event selection process must occur prior to accessing the target. This process must occur if two event models are maintained at a similar level of accessibility, otherwise it is unclear how comprehenders can access the correct event model containing the target. Whereas in panels (c) and (d), if the most recently-mentioned event model is held in working memory then a serial access model could explain why the target is more accessible when maintained in the working model rather than the backgrounded model without the need for an event selection mechanism.

While an exploration into the mechanism behind this event selection process is beyond the scope of this thesis, this process could also be at play in explaining how interference occurs during competitive retrieval for a target represented across multiple event models. However, all figures depicted here are also open to the possibility of access occurring in a parallel fashion, in the sense that event switching needn’t occur in Figure 6.1, Figure 6.2, and Figure 6.3, but rather the backgrounded models are simply less accessible due to the need to retrieve them from long term memory. Moreover, maintaining more than one event model could reduce accessibility for the target due to processing costs associated with the need to access more than one model, rather than the need to maintain more than one model. Similarly, in Figure 6.3 the observed finding of reduced accessibility for the target following a spatial shift (i.e. panels (a) and (b) vs. (c) and (d)) is equally plausible given a serial or parallel access model; in both cases it is likely that the processing costs associated with updating event models following a spatial shift slows access for the correct event model, regardless of whether or not an event selection process occurs. While Experiments 4-6 cannot unequivocally establish whether access for an event model occurs in a parallel or serial fashion, the findings of these experiments may shed light on the most likely interpretation for the processes involved in accessing information within an event model.

Experiments 4-6 aimed to address whether interference on access for an object associated with multiple event models is driven by event competition, i.e. the need to select between relevant events prior to accessing the target, or by event interference, i.e. the irrelevant event model competes while accessing the relevant event model. In effect, these two processes are reflective of a serial and parallel access strategy respectively. Taking into account the confounds associated with each experiment, the most trustworthy finding in this series was reduced accessibility for both instantiations of the object, and increased accessibility for the boundary in the Apart condition (i.e. when the object was associated with multiple event models) than in the Together condition (i.e. when the object was associated with only one model). If these findings are reflective of reduced accessibility for the two instantiations of the object driven by interference on access for the target, then such findings are reflective of event competition, or a serial process for accessing information maintained within event models. This is made clear in Figure 6.4.

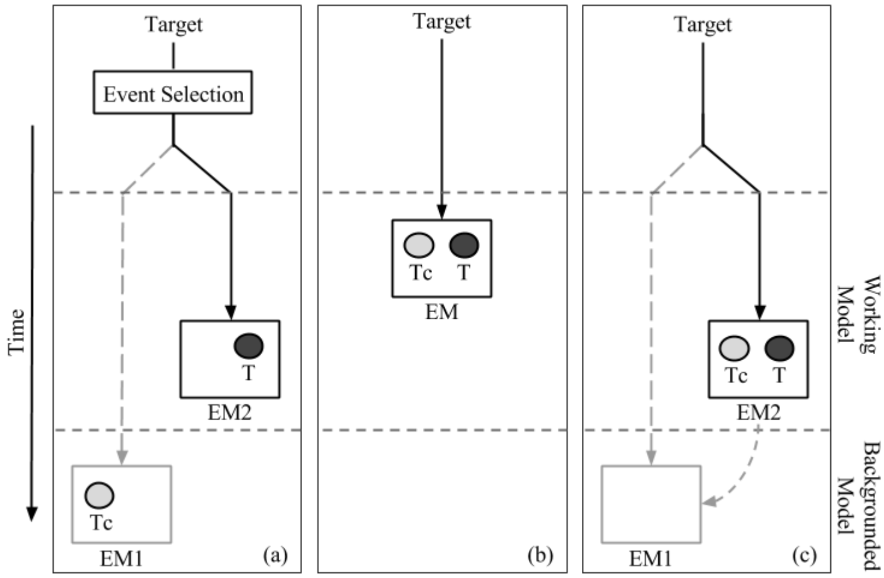


Figure 6.4. Experiments 4-6: A process of Event Model Access where (a) two event models are maintained with the target (i.e. goal) (T) in the working event model (EM2), and the same-object competitor (i.e. source) (Tc) in the backgrounded event model (EM1); (b) one working event model is maintained with the target and same-object competitor in the working event model (EM); (c) two event models are maintained with the target and same-object competitor in the working event model (EM2) and no other objects maintained in a backgrounded event model (EM1)

Panel (a) in Figure 6.4 shows the Apart condition in Experiments 4-6, in which the two instantiations of the object were maintained in separate event models, while panel (b) shows the Together condition, in which the two instantiations of the object were maintained in one event model. Panel (c) shows a theoretical possibility in which the target (i.e. goal) and competitor (i.e. source) were maintained in the same event model, but a backgrounded event model was also maintained (containing no other objects). This panel is used to explain possibilities with the mechanism of interference and access for the target in the Together and Apart conditions where the number of event models maintained is equivalent across conditions.

In the Apart condition (i.e. panel (a)), both the target (T) and competitor (Tc) were less accessible than in the Together condition (i.e. panel (b)), where the target and competitor were maintained in the same event model. Yet in both cases, following the movement of the object from its initial to its final location, Event Segmentation Theory (Radvansky & Zacks, 2011) predicts that the competitor will become less accessible than it was prior to its change in space. Indeed, following this updating of location, the competitor will be suppressed, and in the case of the Apart condition, the backgrounded event model will be suppressed. If the process for accessing the target is serial, in which comprehenders first select between the two event models – accessing the event model containing the target and suppressing the event model containing the competitor – then this selection process should be manifested in reduced accessibility for both the target and competitor in the Apart condition (i.e. panel (a)) when compared to the Together condition (i.e. panel (b)); the most reliant findings across Experiments 4-6. If, instead, parallel access occurs, we should predict increased accessibility for the competitor in the Apart condition (i.e. panel (a)) when compared to the Together condition (i.e. panel (b)) if the backgrounded model is accessed automatically along with the foregrounded model. In this case, we might predict reduced accessibility for the target as a consequence of increased accessibility for the competitor; event interference. However, this effect was not observed. As such, event competition involving the need to select between multiple relevant event models (and suppressing the incorrect model) is the most likely interpretation of the findings from Experiments 4-6. While this does not necessarily preclude the notion that parallel access occurs during non-competitive access (i.e. Experiments 1-3, Experiment 7), the most parsimonious answer involves serial processing in all cases. Note that this argument holds more weight if we assume that in the Together condition comprehenders do not only maintain a working event model for the location containing the target and competitor, but that they also maintain a backgrounded model for the room that was in the visual display, but not entered by the protagonist (i.e. panel (c)). If parallel access and suppression of the competitor is involved in panels (a) and (c), then why would both the target and competitor be less accessible in panel (a) than in panel (c)? Here, it is likely that the only difference between the two is the need to select between multiple relevant event models associated with the target prior to accessing the target (i.e. panel (b)). This relevance of the target to each event model is precisely the factor that Radvansky and colleagues identify as the cause behind the fan effect (Radvansky, 1999) and interference in similar real-world and virtual-reality memory experiments (Radvansky & Copeland, 2006; Radvansky et al., 2011). However, the present thesis has provided a means by which this relevance feeds into the process for event model access, showing that interference is manifested during competitive access likely due to the need to select between multiple relevant event models; if no other models are relevant to the target, selection in this case is unlikely to happen.

While the findings in the experiments reported in this thesis support the interpretation of event access outlined here, it must be noted that further evidence is needed to support whether the processes involved in access occur in a serial or parallel fashion. While

Experiments 4-6 seemingly support the notion that access occurs in a serial fashion, these experiments were not designed specifically to address this question. As such, further research is needed to establish the precise mechanism of event access. However, the model outlined here is useful in that it shows how the principles outlined in the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) can work together during access for an event model. Of note are the implications this model has for foregrounding: there is privileged access for information initially maintained in the working event model prior to accessing the target, a transiently higher level of accessibility for information maintained in the working model prior to switching focus to backgrounded event models, and a consistently higher level of accessibility for information maintained in the accessed model. This model also shows that regardless of whether an event model is foregrounded or not, there are costs associated with maintaining multiple event models and updating event models, in line with the Event Horizon model. Finally, while it is speculated that event competition is the mechanism at play during competitive access for a target, a confirmation of whether access for event models occurs in a serial or parallel fashion is required to confirm this assumption. Regardless of the processes at play, the model outlined above shows that typically the same processes are at play when accessing an event model, but that where information is maintained within the event model and where the event model itself is maintained can modulate accessibility for the targeted information.

The models outlined here, based on theory from the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) and upon the observed data from the present thesis, are designed to work together in a single architecture. In all cases, following Event Segmentation Theory (Radvansky & Zacks, 2011; Zacks et al., 2009), a new event model is constructed and foregrounded on mention following a spatial shift. Creation of a new event model is associated with increased processing costs, and potentially costs to maintaining more than one event model in long term memory, as evidenced in Experiments 2 and 3 of the present thesis. Following the principles of the Event Horizon model, it is assumed that the working event model is privileged, such that information in this event model is more readily available than information in backgrounded event models prior to mention for the target. On mention for the target, the working event model is first searched, prior to 'event switching' if the target is maintained in the backgrounded event model. This accounts for the increased accessibility for potential targets in Experiment 2 if no spatial shift occurred (vs. a spatial shift), as no event switching process was necessary, and potential targets were already foregrounded prior to mention. Moreover, this accounts for the increased availability for semantic competitors when maintained in the same event model as the target in Experiment 7, as well as the hypothesised transient peak in accessibility for the semantic competitor in Experiment 7 when located in a different, but initially foregrounded event model to the target. Such a mechanism can also account for the increased accessibility for the target in Experiment 3 if no spatial shift occurred and the target was in the backgrounded, but recently mentioned, location. This mechanism is not controversial given the well reported effects of foregrounding in the situation model literature (Glenberg et al., 1987).

When comprehenders attempt to access one instantiation of a target represented across multiple event models (i.e. Experiments 4-6), interference occurs. Here, the target is less accessible even when maintained in the foregrounded event model. As such, another process to the serial access model described above must be at play when accessing the target. Here, it is predicted that when more than one event model is relevant to the target, prior to access for the target an event selection process must occur; the more event models relevant to the target, the more difficult this process becomes (Radvansky, 1999). Because the competitor should be suppressed regardless of whether it is maintained in one event model or more, it is unlikely that all event models are accessed, but rather are considered prior to selecting the correct model. Such a mechanism is likely to be at play when no event model is foregrounded, as in the Shift conditions in Experiment 3. Again, a serial process is predicted to be at play here due to the predicted transient peak in accessibility for objects in an initially foregrounded location prior to access for the target, i.e. panel (d) in Figure 6.2, however further explorations are required prior to accepting the aforementioned models as a serial or parallel process. Regardless, as discussed above, it is predicted that the models outlined here work together for a singular event access architecture adhering to the principles of the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) and generalising to any scenario that is similar to those discussed above.

6.1.5. Future Directions and Improvements to the Current Research Paradigm

As noted in Section 6.1.4, while the data from Experiments 4-6 indicate that event selection occurs during competitive access for a target, indicating that access for an event model occurs in a serial fashion, it is essential to confirm this claim in further studies. Comparing computational simulations of a serial and parallel access model to behavioural data would likely establish the mechanism of access, allowing for more confident assessments of whether comprehenders access event models in the hypothesised serial fashion, or in a parallel fashion instead. Within the scope of the present set of experiments, however, a number of improvements could be made to confirm the claims of event access laid out here. Namely, Experiments 1 and 3 highlight the need for the design to ensure that comprehenders rely on an event model during narrative comprehension.

In contrast to Experiment 1, Experiment 2 showed that removing the visual scene prior to the onset of discourse ensured that comprehenders relied on an event model when understanding a narrative. In this case, removal of the visual scene ensured that no visual foregrounding could occur, and that comprehenders were more likely to rely on an event model or on the imagined location of the protagonist when processing the narrative, and comprehenders were less likely to rely on the ‘here and now’ in the visual scene. This is not to say that in order to ensure that comprehenders rely on an event model the visual scene cannot be co-present, as the scene was also co-present in Experiments 3, 4, 6, and 7. However, in Experiments 3 and 7 the visual display did not depict any one location described in the narrative, such that any difference in accessibility for the objects in the display could only be driven by the event models relied upon during comprehension. Furthermore, in Experiments 4 and 6 (and in the blank-screen version of Experiment 4; Experiment 5) both locations were equally visually foregrounded across conditions, such that visual foregrounding could not have driven a strategy of focusing on one location over another. What is crucial then, is not whether or not a location is visually foregrounded, but to ensure that the locations in a narrative are equally visually foregrounded (or, equally visually unavailable) to ensure that comprehenders rely on the imagined location of the protagonist/objects, rather than on only what is depicted in the visual scene.

In order to observe effects of foregrounding it is crucial to ensure that comprehenders take the perspective of the protagonist when processing the narrative. In Experiment 3, the narrative did not explicitly make clear which character was the protagonist, and likely failed to find any effect of foregrounding in the Shift conditions – i.e. increased accessibility for objects in the same location as the protagonist – as comprehenders did not take the perspective of the most recently mentioned character, which was presumed to be the case during the design of the experiment. Because perspective-taking is a crucial factor in determining whether or not foregrounding influences accessibility for a target (e.g. Rapp, Klug, & Taylor, 2006), further experiments should ensure that comprehenders take the perspective of a character as intended during the design of the experiment. Finally, to further ensure that comprehenders rely on an event model during comprehension, future experiments should attempt to reduce the degree of predictability within the narratives such that accessibility for a target is driven by an understanding of the narrative reliant upon the event model, and not by prediction for a likely target. Experiment 6 suffered from this confound, the result of which is a potential processing strategy that is less reliant on the event model during comprehension, reducing the likelihood that any differences in the event models across conditions can influence eye-movement behaviour on access for the target. With the above changes, further studies can more confidently assess the influence of the event model structure on discourse processing under the assumption that comprehenders rely on the event model to process the narrative.

The most pressing improvements to the current series of experiments lie in the design and findings of Experiments 4-7. In Experiment 4-6, it is difficult to divorce the proportion of fixations on the source and goal from the proportion of fixations on the boundary. While Experiment 6 aimed to address whether reducing the size of the boundary between the source and goal influenced the proportion of fixations on the source and goal, using highly predictable narratives (with no fillers) and failing to orthogonally manipulate condition and boundary-type made it impossible to detect whether the increased proportion of fixations on the boundary in the Apart (vs. Together) condition was driven by having a large and highly visually salient object between the source and goal which reduced the proportion of fixations on other objects in the visual display, or whether the proportion of fixations on the boundary were independent of the proportion of fixations on the source and goal. It is therefore essential for further work to explore whether the difference in the proportion of fixations on the boundary, source, and goal across conditions are reflective of different processing strategies associated with interference when accessing the target, or of low-level visual differences across conditions. In regards to Experiment 7, further work must establish whether the modulation of semantic competition on access for a target is driven by association of the objects with the same or different event models or by association with the same or different sentences. This could be achieved by setting up sentences in which the locations of each object are stated individually either in the same or separate sentences, as outlined in Example 5.2. In implementing these changes, it is also possible to manipulate which model is initially foregrounded, confirming whether transient competition occurs in cases when the target and competitor are in separate models, but the competitor is initially in the foregrounded model, but not when the target is in the foregrounded model and the competitor in the backgrounded model. This will allow for confirmation of the claims made in Section 6.1.4 concerning panels (b) and (d) of Figure 6.2. By implementing the above changes, further studies can help to confirm the influence of event model structure on competition during access for a target.

6.2. General Conclusions

In response to the main aims of this thesis, the series of experiments conducted here have established that comprehenders can and do build an event model without the requirement for explicit instruction to do so. That is, during passive listening tasks, accessibility for information within a narrative is modulated by the spatial structure of the event model constructed during comprehension. Experiment 2 confirmed that, during passive listening, comprehenders construct a spatial model built around categorical rather than Euclidean distance, with accessibility for potential targets described in an initial location reduced if a protagonist makes a shift to a new location (vs. no shift) – regardless of how far away it is. Experiment 3 built upon this finding, showing that updating an event model following the movement of a protagonist from one location to another causes a reduction in accessibility for a target on mention, regardless of whether this shift is to or from the location containing the target. To date, these findings are unique in the event model literature, showing that comprehenders can spontaneously construct and utilise event models during comprehension, and that these models influence how information is accessed during discourse processing. However, as noted in Section 6.1.5, it is likely that comprehenders only do so when an event model is necessary for understanding the unfolding narrative, but this needn't necessitate the use of a particular task during comprehension (cf. Zwaan & van Oostendorp, 1993); when the model itself provides no more information than simple low-level referential processing, or when conditions draw attention away from the event model (as in Experiment 1), it is unlikely that comprehenders will utilise an event model.

Building upon the findings that comprehenders can spontaneously construct an event model built around categorical space during comprehension, Experiments 4-6 were designed to expand on the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012), asking how interference is manifested when an object is associated with multiple event models (vs. one event model). Here, the aim was to establish not just when interference occurs, but how it is manifested, with the hope to establish a mechanism of event access for the principles outlined in the Event Horizon model. Considering the range of designs across the three experiments and the results that these designs yielded, the most consistent finding was indeed interference on access for an object when associated with two, rather than one, event model. This interference was manifested in a reduction in accessibility for both instantiations of the object on mention of the object, suggesting that competition between the two event models occurs on access for the object. Section 6.1.4 outlines a potential mechanism for this competition, in which the event models relevant to the object are considered and selected between prior to access for the correct model containing the updated instantiation of the object, reducing accessibility for both instantiations of the object as compared to cases when only one model is maintained. While the mechanism outlined in Section 6.1.4 provides only a working model to describe the observed data, it is hoped that this model provides a benchmark with which to test against future studies; exploring specifically whether access for event models occurs in serial or parallel fashion. Regardless of the precise mechanism at play, this series of experiments has shown that the interference associated with maintaining an object across multiple event models is not restricted only to the updated instantiation of the object, but cascades to both instantiations of the object. In this way, these findings are again unique in the present literature, establishing the precise consequences for the principle of interference outlined in the Event Horizon model.

Finally, Experiment 7 aimed to explore a rather understudied area of the event model and event cognition literature; that of the positive influences of event segmentation on accessibility for information maintained in event models. In concert with this aim, this experiment aimed to establish whether the effects of foregrounding could be detected using eye-tracking methods, an aim that was not met in Experiment 3. Here, association of a target and semantically-related competitor with different event models (vs the same event model) reduced the amount of semantic competition on access for the target. In this way, segmentation of information into separate event models can act to reduce competition on access for a target, thereby increasing the accessibility for the target. These findings thus showed that when multiple event models are maintained, foregrounding can modulate the degree of competition found on access for a target, and that event model structure can have positive influences on accessibility for information in discourse processing. Furthermore, this experiment also established that foregrounding can modulate accessibility for information during discourse processing irrespective of any cost to switching focus from one event model to another (see Chapter 5 for a detailed discussion).

Together, the experiments conducted in this thesis have broadly confirmed that space is represented categorically, and that the principles of the Event Horizon model (Radvansky & Zacks, 2014; Radvansky, 2012) hold true during passive listening tasks in discourse comprehension. These experiments have shown that changes to event model structure modulate accessibility for information during anticipation and on access, and can specifically modulate competition on access for this information. Specifically, the present thesis has further contributed to an understanding of how interference is manifested during competitive retrieval for an object, providing a potential mechanism for this process. Finally, the work in this thesis has helped to establish the positive effects of event structure on accessibility for information, showing how event model structure can modulate competition in order to improve accessibility for a target on access. While further work is needed to establish the precise mechanism for event model access, and to explore the role of potential confounds in the above studies, the model proposed in Section 6.1.4 provides a framework with which to test future research against, showing how the principles of the Event Horizon model work together. The body of work presented here sought to establish whether comprehenders can construct an event model without an overt task, asking if so, how this model is represented and what its consequences are for comprehension. From the present evidence, it is likely that the general principles of the Event Horizon model hold true when comprehenders must rely on an event model; that space is organised categorically into separate event models, and that the models we focus on, and how information is represented across these models, can influence the accessibility for information in discourse processing.

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Appendices

Appendix A

Appendix A.1. Sentential Stimuli used in Experiments 1 & 2

There were 3 versions of each discourse for each experimental item, corresponding to the ‘same’, ‘near’, and ‘far’ conditions, related to the location of the protagonist during the second and third sentences. In all items here, sentence ‘iia’ represents the ‘same’ condition, ‘iib’ represents the ‘near’ condition, and ‘iic’ represents the ‘far’ condition. All items contain 3 versions of sentence ‘ii.’ corresponding to the 3 conditions; however practice items contain 2 ‘same’ location nouns, 1 ‘near’, and 1 ‘far’ noun.

Sentence ‘i’ in the practice, experimental, and filler items describes a protagonist (unique across all items), looking towards 2 objects. In these items the verb phrase is repeated 4 times across experimental and filler items, but is unique in practice items. The target and competitor (i.e. the two objects mentioned in the first sentence) are unique across all items, as are the unmentioned distractor objects. Sentence ‘ii’ describes 1 of 3 time frames, ‘*Minutes later*’ (short), ‘*An hour later*’ (intermediate), ‘*A day later*’ (long), in which the next event takes place. The time-frame for the events was the same across all conditions of each item, but varies equally across items. A verb phrase then describes the protagonist carrying out a task. This verb phrase is repeated 4 times across experimental and filler items, but is unique in practice items. Following the described task, a noun specifies the location of the protagonist. This location noun is unique across all items. Sentence ‘iii’ describes the protagonist thinking about the target. This verb phrase is repeated 4 times across all items, but is unique in practice items. The order of mention for the target is balanced to be either the first or second mentioned objects in sentence ‘i’ across all items. Finally, a post-noun phrase follows the mention of the target and is unique across all items. All experimental items take the form of the given example:

i. The girl notices the <u>nuts</u> and the <u>*kite*</u> at the **park**.

iia. *A day later,* she runs at the **park**.
iib. *A day later,* she runs at the footpath.
iic. *A day later,* she runs at the factory.
iii. And remembers that the <u>*kite*</u> must be fun to play with.

The underlined and italicised noun (e.g. *kite*) corresponds to the target object, and the underlined noun (e.g. nuts) corresponds to the competitor object. The bold noun corresponds to the initial location of the protagonist (e.g. **park**). The italicised phrase corresponds to the time shift (short/intermediate/long: e.g. for intermediate, '*A day later*'). The spatial conditions correspond to the final location of the protagonist: within sentence 'ii', 'a' corresponds to the 'same' condition, 'b' to the 'near' condition, and 'c' to the 'far' condition. Finally, reference is made back to the target object (e.g. *kite*). A post noun phrase follows to complete the narrative, to allow for observation of any post-noun fixations (e.g. '…*must be fun to play with*').

Filler items took the same form as the experimental items, however only one of the three conditions was used with each item (same, near, far), with this order balanced across items. While all of the items describe objects that were present in the visual scene in 'i', in 'iii' half of the trials referred to another unmentioned object in the visual scene, and half referred to another object that was not present in the visual scene and was also previously unmentioned. For the practice items, two experimental-type and two filler-type items were used. For the filler-type items, the discourse reflected the same and far conditions. For the experimental-type items, the discourse reflected the same and near conditions, with the target located in the first-mentioned and second-mentioned positions in sentence 'i' respectively.

Appendix A.1.1. Experimental Sentences

1i. The boy gazes at the picture and the chair in the room.

iia. An hour later, he sings in the room.

iib. An hour later, he sings in the laundry-room.

iic. An hour later, he sings in the playground.

iii. And thinks about how the picture is very beautiful.

2i. The girl notices the nuts and the kite at the park.

iia. A day later, she runs at the park.

iib. A day later, she runs at the footpath.

iic. A day later, she runs at the factory.

iii. And remembers that the kite must be fun to play with.

3i. The doctor searches the wallet and the t-shirt in the lounge.

iia. An hour later, she relaxes in the lounge.

iib. An hour later, she relaxes in the back yard.

iic. An hour later, she relaxes in the waiting room.

iii. And contemplates about how the wallet is very expensive.

4i. The father stares at the pineapples and the sock in the playroom.

iia. Minutes later, he hums in the playroom.

iib. Minutes later, he hums in the playroom garage.

iic. Minutes later, he hums in the playroom shop.

iii. And recalls that the sock must be tidied away.

5i. The teenager identifies the grandfather clock and the Persian rug in the drawing room.

iia. An hour later, she paces in the drawing room.

iib. An hour later, she paces in the conservatory.

iic. An hour later, she paces in the spa.

iii. And wishes that the grandfather clock could be sold for a good profit.

6i. The policeman observes the bench and the toy boat at the lake.

iia. A day later, he stands at the lake.

iib. A day later, he stands at the bridge.

iic. A day later, he stands at the airport.

iii. And wonders about when the toy-boat was made.

7i. The executive watches the blackboard and the laptop in the office.

iia. Minutes later, she yawns in the office.

iib. Minutes later, she yawns in the reception.

iic. Minutes later, she yawns in the hairdressers.

iii. And ponders over replacing the blackboard with a new one.

8i. The cleaner spots the spoon and the fridge-freezer in the kitchen.

iia. An hour later, she lingers in the kitchen.

iib. An hour later, she lingers in the shed.

iic. An hour later, she lingers in the tax office.

iii. And considers cleaning the fridge-freezer once more.

9i. The waiter locates the glass and the candle in the restaurant.

iia. A day later, he sneezes in the restaurant.

iib. A day later, he sneezes in the carpark.

iic. A day later, he sneezes in the train station.

iii. And dwells over how the glass was expertly crafted.

10i. The nanny inspects the dummy and the rattle in the nursery.

iia. Minutes later, she coughs in the nursery.

iib. Minutes later, she coughs in the foyer.

iic. Minutes later, she coughs in the tourist office.

iii. And deliberates over when the rattle was bought.

11i. The workman checks the ladder and the fence in the yard.

iia. Minutes later, he whistles in the yard.

iib. Minutes later, he whistles in the street.

iic. Minutes later, he whistles in the carvery.

iii. And reflects over whether the ladder is in working order.

12i. The businessman detects the hat and the vacuum in the hallway.

iia. A day later, he stretches in the hallway.

iib. A day later, he stretches in the terrace.

iic. A day later, he stretches in the meadow.

iii. And realises that the vacuum wastes too much energy.

13i. The mother sees the watch and the television in the front room.

iia. Minutes later, she waits in the front room.

iib. Minutes later, she waits in the corridor.

iic. Minutes later, she waits in the bistro.

iii. And believes that the watch displays the wrong time.

14i. The grandfather looks at the football and the cone on the village green.

iia. An hour later, he strolls on the village green.

iib. An hour later, he strolls on the pavement.

iic. An hour later, he strolls on the cliffs.

iii. And supposes that the cone was used for sports.

15i. The lifeguard studies the diving board and the towel at the swimming pool.

iia. A day later, she walks at the swimming pool.

iib. A day later, she walks at the staff room.

iic. A day later, she walks at the motorway.

iii. And presumes that the diving-board may need to be refitted.

16i. The barman examines the beer and the sandwich in the bar.

iia. Minutes later, he rests in the bar.

iib. Minutes later, he rests in the basement.

iic. Minutes later, he rests in the bus stop.

iii. And ruminates over how the sandwich must be very tasty.

17i. The lady distinguishes the scooter and the newspapers in the high-street.

iia. An hour later, she wanders in the high-street.

iib. An hour later, she wanders in the rugby field.

iic. An hour later, she wanders in the woods.

iii. And questions who the scooter belongs to.

18i. The soldier investigates the jeep and the box in the base.

iia. A day later, he sighs in the base.

iib. A day later, he sighs in the guard tower.

iic. A day later, he sighs in the city.

iii. And debates over whether the box will be picked up soon.

19i. The grandmother gazes at the barbeque and the washing line in the garden.

iia. Minutes later, she hums in the garden.

iib. Minutes later, she hums in the craft room.

iic. Minutes later, she hums in the greengrocer's.

iii. And wishes that the barbeque could be a little larger.

20i. The pirate notices the banana and the shell at the beach.

iia. An hour later, he paces at the beach.

iib. An hour later, he paces at the surf shop.

iic. An hour later, he paces at the car dealership.

iii. And wonders whether the shell is worth any money.

21i. The sailor searches the sandcastle and the boat at the harbour.

iia. A day later, he stands at the harbour.

iib. A day later, he stands at the resort.

iic. A day later, he stands at the oil rig.

iii. And ponders over whether the sandcastle will last very long.

22i. The sightseer stares at the blanket and the rocket at the launch site.

iia. Minutes later, she yawns at the launch site.

iib. Minutes later, she yawns at the viewing stands.

iic. Minutes later, she yawns at the supermarket.

iii. And considers whether the rocket will make it to the moon.

23i. The camper identifies the fire and the tent at the range.

iia. An hour later, she lingers at the range.

iib. An hour later, she lingers at the loch.

iic. An hour later, she lingers at the highway.

iii. And dwells over whether the fire is safe.

24i. The attendant observes the train and the umbrella at the platform.

iia. A day later, she sneezes at the platform.

iib. A day later, she sneezes at the ticket office.

iic. A day later, she sneezes at the barber's.

iii. And deliberates over whether the umbrella belongs to a passenger.

25i. The shopper watches the flowers and the bin in the city centre.

iia. Minutes later, she coughs in the city centre.

iib. Minutes later, she coughs in the taxi rank.

iic. Minutes later, she coughs in the racecourse.

iii. And reflects over whether the flowers could make a nice gift.

26i. The student spots the radio and the scarf in the common room.

iia. An hour later, he whistles in the common room.

iib. An hour later, he whistles in the cafeteria.

iic. An hour later, he whistles in the swamp.

iii. And realises that the scarf is hand-made.

27i. The mechanic locates the paint and the hardhat in the workshop.

iia. A day later, he stretches in the workshop.

iib. A day later, he stretches in the driveway.

iic. A day later, he stretches in the boulevard.

iii. And believes that the paint is the wrong colour.

28i. The competitor inspects the medal and the skipping rope in the field.

iia. Minutes later, he waits in the field.

iib. Minutes later, he waits in the box office.

iic. Minutes later, he waits in the pharmacy.

iii. And supposes that the skipping-rope should be stored away.

29i. The tourist checks the camera and the barrel at the quay.

iia. An hour later, she strolls at the quay.

iib. An hour later, she strolls at the hotel.

iic. An hour later, she strolls at the lighthouse.

iii. And presumes that the camera was lost by a stranger.

30i. The paramedic detects the stretcher and the motorbike in the grounds.

iia. A day later, she walks in the grounds.

iib. A day later, she walks in the chemist's.

iic. A day later, she walks in the forest.

iii. And ruminates over whether the motorbike was parked by a patient.

31i. The lecturer sees the tree and the books in the campus.

iia. Minutes later, he rests in the campus.

iib. Minutes later, he rests in the student's union.

iic. Minutes later, he rests in the outlet store.

iii. And questions how long the tree has been growing.

32i. The shop-assistant looks at the jar and the till in the corner shop.

iia. An hour later, she wanders in the corner shop.

iib. An hour later, she wanders in the stock room.

iic. An hour later, she wanders in the school.

iii. And debates over whether the till was costly to buy.

33i. The boxer studies the heavy-bag and the boxing gloves at the gymnasium.

iia. A day later, he sighs at the gymnasium.

iib. A day later, he sighs at the lobby.

iic. A day later, he sighs at the running track.

iii. And thinks that the heavy-bag is a little too soft.

34i. The teacher examines the bell and the apple in the classroom.

iia. Minutes later, she sings in the classroom.

iib. Minutes later, she sings in the teacher's lounge.

iic. Minutes later, she sings in the school yard.

iii. And remembers that the apple will make a nice snack.

35i. The delivery-man distinguishes the forklift truck and the barrier in the warehouse.

iia. An hour later, he runs in the warehouse.

iib. An hour later, he runs in the security office.

iic. An hour later, he runs in the theatre.

iii. And contemplates whether the forklift truck is safe to drive.

36i. The scientist investigates the filing cabinet and the Bunsen burner in the laboratory.

iia. A day later, he relaxes in the laboratory.

iib. A day later, he relaxes in the toilets.

iic. A day later, he relaxes in the tennis courts.

iii. And recalls that the Bunsen burner is still alight.

Appendix A.1.2. Filler Sentences

37i. The warden gazes at the bucket and the American football at the lakeside.

ii. Minutes later, he yawns at the lakeside.

iii. And wonders whether the backpack has been abandoned.

38i. The zoologist notices the car and the animal skull in the savannah.

ii. An hour later, she lingers in the savannah.

iii. And ponders over whether the aeroplane is off-course.

39i. The director searches the 3-D glasses and the cinema in the retail park.

ii. A day later, he sneezes in the retail park.

iii. And considers whether the popcorn is overpriced.

40i. The librarian stares at the footstool and the calculator in the library.

ii. Minutes later, she coughs in the library.

iii. And dwells over whether the credit-card has been lost.

41i. The dentist identifies the lamp and the recycling bin in the dental surgery.

ii. An hour later, she whistles in the porch.

iii. And deliberates over whether the fly swatter should be cleaned.

42i. The hitch-hiker observes the clouds and the road-sign at the road side.

ii. A day later, he stretches at the bed and breakfast.

iii. And reflects over whether the registry book had been updated recently.

43i. The bouncer watches the DJ equipment and the wine bottle in the club.

ii. Minutes later, he waits in the alley.

iii. And realises that the drain must have been blocked.

44i. The gardener spots the shears and the shovel in the greenhouse.

ii. An hour later, she strolls in the charity shop.

iii. And believes that the carrots were a good harvest.

45i. The conservationist locates the lily pad and the net by the river bank.

ii. A day later, she walks by the sea.

iii. And supposes that the lifeboat had been there a long time.

46i. The farmer inspects the sacks and the hay bale at the farm.

ii. Minutes later, he rests at the cottage.

iii. And presumes that the oven was a worthwhile investment.

47i. The traveller checks the bone and the cactus in the outback.

ii. An hour later, she wanders in the outback.

iii. And ruminates over whether the sun will stay up much longer.

48i. The racer detects the video-camera and the chequered flag at the race-track.

ii. A day later, he sighs at the race-track.

iii. And questions whether the debris will be moved before the race.

49i. The musician sees the disc and the cap in the recording studio.

ii. Minutes later, she sings in the arena.

iii. And debates whether the drum set will be used soon.

50i. The security-guard looks at the trolley and the safe in the vault.

ii. An hour later, he runs in the cathedral.

iii. And thinks that the crown was left out in the open.

51i. The foreman studies the crane and the coffee at the construction site.

ii. A day later, he relaxes at the lodge.

iii. And remembers that the blueprint doesn't cover everything required.

52i. The bowler examines the bowling pins and the bowling ball in the bowling alley.

ii. Minutes later, he hums in the computer shop.

iii. And contemplates about whether the hard-drive need repairs.

53i. he player distinguishes the dart board and the pool table in the pub.

ii. An hour later, he paces in the off-license.

iii. And recalls that the cigar appeared to be broken.

54i. The jockey investigates the gate and the window in the stables.

ii. A day later, he stands in the mansion.

iii. And wishes that the ornament were a little larger.

55i. The daughter gazes at the water gun and the pinball machine in the arcade.

ii. Minutes later, she coughs in the arcade.

iii. And ponders over the slot machine and whether it will pay out.

56i. The skateboarder notices the wall and the railing in the skate park.

ii. An hour later, he whistles in the skate park.

iii. And considers whether the headphones look cool.

57i. The auntie searches the security camera and the escalator in the mall.

ii. A day later, she stretches in the mall.

iii. And dwells on how the buggy shouldn't be left alone.

58i. The waitress stares at the coffee machine and the light shade in the coffee shop.

ii. Minutes later, she waits in the coffee shop.

iii. And deliberates over whether the menu should be updated.

59i. The golfer identifies the golf ball and the sand bunker at the golf course.

ii. An hour later, he relaxes at the club house.

iii. And reflects over whether the caddy can fit another passenger.

60i. The cook observes the purse and the door in the diner.

ii. A day later, she walks in the layby.

iii. And realises that the bush is overgrown.

61i. The miner watches the lantern and the pick-axe in the mine.

ii. Minutes later, he rests in the food hall.

iii. And believes that perhaps the walkie-talkie is malfunctioning.

62i. The explorer spots the igloo and the mountain in the tundra.

ii. An hour later, she wanders in the tundra.

iii. And supposes that the satellite may have frozen.

63i. The beautician locates the sunglasses and the high-heel shoe in the tanning salon.

ii. A day later, she sighs in the dressing-room.

iii. And presumes that the hair dryer needs a safety check.

64i. The grave digger inspects the skull and the coffin in the cemetery.

ii. Minutes later, he sings in the crematorium.

iii. And ruminates over whether the card was left recently.

65i. The distiller checks the distilling equipment and the whisky bottle in the distillery.

ii. An hour later, he runs in the museum.

iii. And questions whether the relic is genuine.

66i. The owner detects the trowel and the grapes in the vineyard.

ii. A day later, she strolls in the pressing-room.

iii. And debates over whether the well is safe to drink from.

67i. The astronomer sees the printer and the telescope in the observatory.

ii. Minutes later, she hums in the observatory.

iii. And thinks that the monocle must be brand new.

68i. The pilot looks at the screwdriver and the magnifying-glass at the heliport.

ii. An hour later, he paces at the showroom.

iii. And remembers that the keys were a replacement.

69i. The street sweeper studies the Ferris wheel and the hotdog stand in the fair.

ii. A day later, he stands in the avenue.

iii. And contemplates whether the teddy-bear is a good prize.

70i. The figure skater examines the hockey stick and the ice-skates in the ice-rink.

ii. Minutes later, she yawns in the ice-rink.

iii. And recalls that the mittens were very small.

71i. The archer distinguishes the tape measure and the binoculars at the grassland.

ii. An hour later, she lingers at the pond.

iii. And wishes that the pebbles could be removed.

72i. The snowboarder investigates the snowman and the goggles at the slope.

ii. A day later, she sneezes at the village.

iii. And wonders if the pogo stick will be claimed soon.

Appendix A.1.3. Practice Sentences

73i. The boss studies the girder and the digger in the quarry.

ii. Minutes later, he treads in the quarry.

iii. And assumes that the drill is sufficient for the job.

74i. The athlete views the racquet and the shorts in the squash-court.

ii. An hour later, she idles in the squash-court.

iii. And deduces that the racquet must have recently been bought.

75i. The model peruses the mountain and the sun-lotion at the lagoon.

ii. A day later, she poses at the villa.

iii. And reckons that the lilo must take a while to inflate.

76i. The prisoner marks the bunk and the handcuffs in the jail-cell.

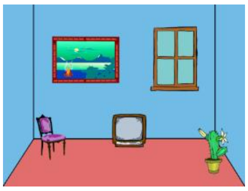
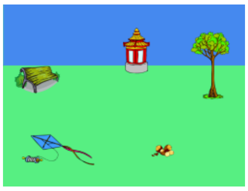
ii. Minutes later, he squats in the exercise-yard.

iii. And figures that the handcuffs were lost during an inspection.

Appendix A.2. Visual Stimuli used in Experiments 1 & 2

All visual stimuli displayed here are scaled down from the original 800 x 600 pixels. Visual stimuli were displayed with a 200 pixel grey border around the perimeter. Below, stimuli with a lightly coloured background have an added black border for ease of viewing, however this was not necessary to include in the experiment due to the inclusion of the 200 pixel grey border.

Appendix A.2.1. Experimental Scenes

1. 
2. 
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5. 
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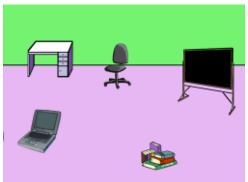
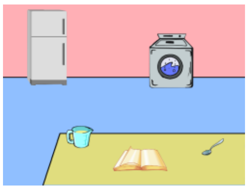
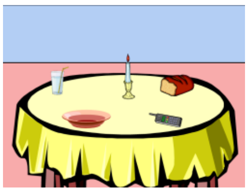
7. 
8. 
9. 
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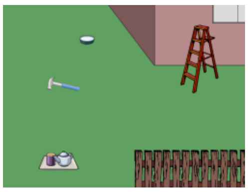
11. 
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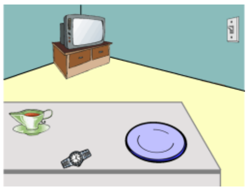
13. 
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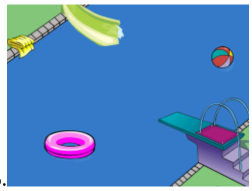
15. 
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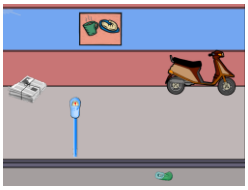
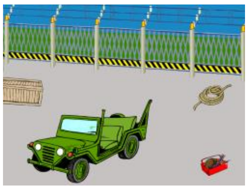
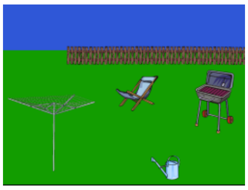
17. 
18. 
19. 
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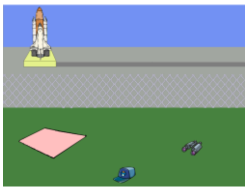
22. 
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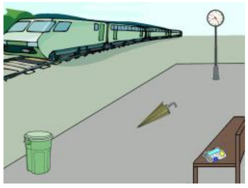
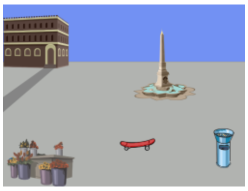
24. 

25. 
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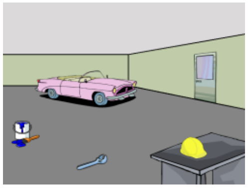
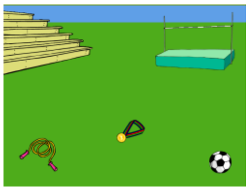
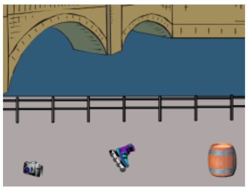
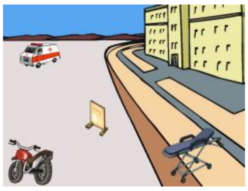
27. 
28. 

29. 
30. 
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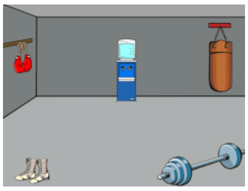
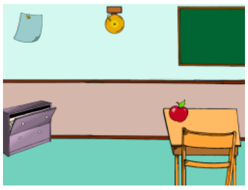
33. 
34. 
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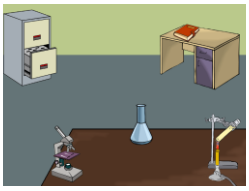
36. 

Appendix A.2.2. Filler Scenes

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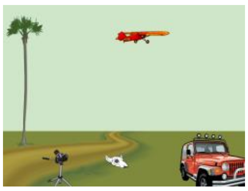
38. 
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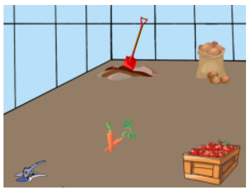
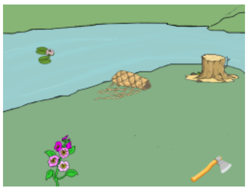
44. 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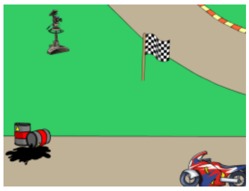
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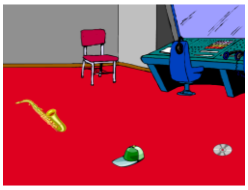
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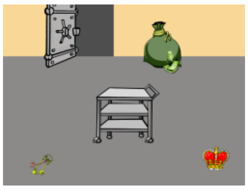
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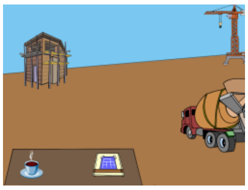
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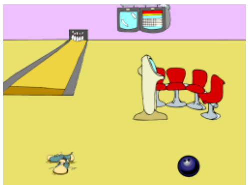
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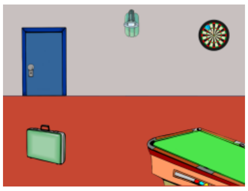
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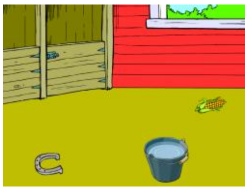
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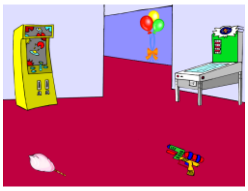
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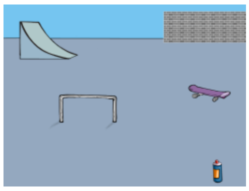
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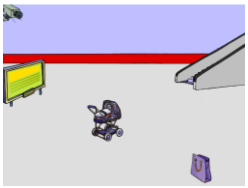
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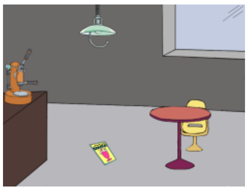
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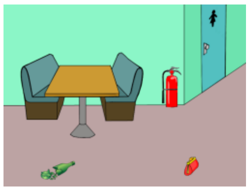
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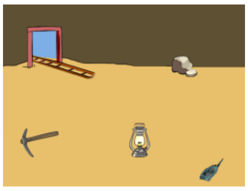
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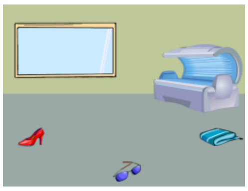
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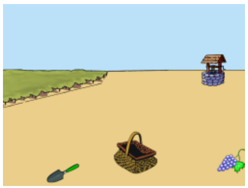
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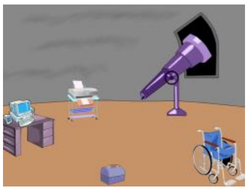
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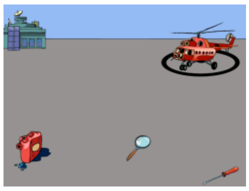
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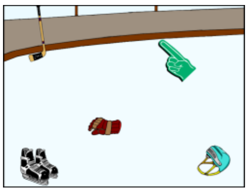
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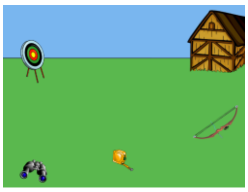
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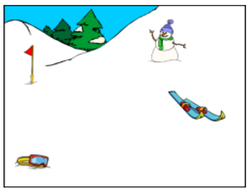
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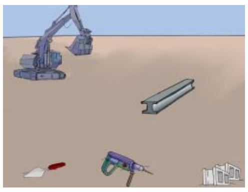
Appendix A.2.3. Practice Scenes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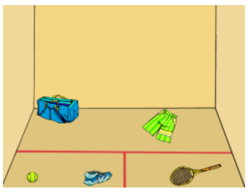
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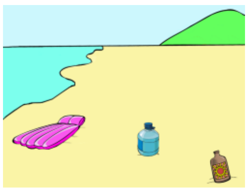
75.

76.

Appendix A.3. Data Preparation and Models for Analysis during the critical noun ('picture') in Experiment 1

For both by-participants and by-items analyses fixations were transformed to the empirical logit (`elog`) as follows, where `y` is the number of fixations within an interest area in each bin, and `N` is the total number of frames within each bin (i.e. the number of items per condition × the number of frames per bin):

```
df2$elog <- log((df2$y + .5) / (df2$N - df2$y + .5))
```

Both models contained fixed effects of condition (`condition`) and fixed effects of time on the linear orthogonal term (`ot1`). Orthogonal time terms were calculated using the `poly` function over the samples of each time bin to the required degree (in this case, to the first degree). Both models contained maximal random effects structures (and their correlations) of participants/items (`by`) and participants/items by condition (`by:condition`) on the linear orthogonal time term. The '`by`' factor took on the properties of participants/items depending upon the analysis used; hence the model structure is the same across both analyses even if its contents differ. In both, weights were calculated as follows, where `y` is the number of fixations within an interest area in each bin, and `N` is the total number of frames within each bin:

```
df2$wts <- with(df2, 1/(df2$y + .5) + 1/(df2$N - df2$y + .5))
```

This weighting (`wts`) was then used in the full model:

Appendix A.3.1. Calculating the empirical logit for the (transformed) fixations on the target (picture) during the critical noun ('picture'):

```
m.elog <- lmer(elog ~ (ot1)*condition + (ot1 | by) +
(ot1 | by:condition),data=df2, weights=1/wts, REML=FALSE)
```

Appendix A.4. *p*-value calculations using the glht function from the multcomp library

Following the method outlined by (Mirman, 2014), a contrast matrix was first set up to define the comparisons for each test. In this matrix, each column responds to a parameter estimate from the original model in the order displayed in the output, and each row corresponds to the contrast to test. In this row, values are weighted to establish which contrast to calculate, such that if an estimated parameter is required a 1 is placed in the column corresponding to that value, and a 0 is placed in all others. If, however, the difference between two estimates is required, a -1 and 1 is placed in each column corresponding to their estimates, respectively. An example of this contrast matrix is displayed below, corresponding to the calculations for all contrasts for the transformed proportion of fixations on the target during '*picture*' in Experiment 1.

```
contrast.matrix <- rbind(
  "a vs. b" = c(0, 0, 0, 1, 0, 0, 0, 0, 0),
  "a vs. c" = c(0, 0, 0, 0, 1, 0, 0, 0, 0),
  "b vs. c" = c(0, 0, 0, -1, 1, 0, 0, 0, 0),
  "ot1: a vs. b" = c(0, 0, 0, 0, 0, 1, 0, 0, 0),
  "ot1: a vs. c" = c(0, 0, 0, 0, 0, 0, 1, 0, 0),
  "ot1: b vs. c" = c(0, 0, 0, 0, 0, -1, 1, 0, 0),
  "ot2: a vs. b" = c(0, 0, 0, 0, 0, 0, 0, 1, 0),
  "ot2: a vs. c" = c(0, 0, 0, 0, 0, 0, 0, 0, 1),
  "ot2: b vs. c" = c(0, 0, 0, 0, 0, 0, 0, -1, 1))
```

Following generation of the contrast matrix, the `glht` function from the `multcomp` package is used to compute the pairwise comparisons, drawing on the contrast matrix and the model itself:

```
comps<-glht(m.elog, contrast.matrix)
```

Finally, the `summary` function is used to get a list of the parameter estimates, standard errors, z-values and *p*-values for all comparisons:

```
summary(comps)
```

Appendix B

Appendix B.1. Models for Analyses during both Time Windows in Experiment 2

For both by-participants and by-items analyses, fixations were transformed using the empirical logit (`elog`), using a similar method outlined in Appendix A.3. For the analysis for the proportion of fixations on the target on the onset of the critical noun ('picture') `elog` represents the proportion of fixations on the picture only; however, during the anticipatory region ('about how') `elog` represents the proportion of fixations on both the target and competitor. Both models contain fixed effects of condition (`condition`) and fixed effects of time; using linear orthogonal polynomials for the first analysis (`ot1`) and linear and quadratic orthogonal polynomials for the second analysis (`ot1+ot2`). Both models contain random effects (and their correlations) of participants/items (`by`) and participants/items by condition (`by: condition`) for both time terms. The '`by`' factor took on the properties of participants/items depending upon the analysis used; hence the model structure is the same across both analyses even if its contents differ. In both, weights were calculated in a similar manner to that in Appendix A.3. Furthermore, *p*-values were calculated in the manner outlined in 0.

Appendix B.1.1. Calculating the empirical logit for the (transformed) fixations on the target (picture) during the critical noun ('picture'):

```
m.elog <- lmer(elog ~ ot1*condition + (ot1 | by) +
(ot1 | by:condition),data=df2, weights=1/wts, REML=FALSE)
```

Appendix B.1.2. Calculating the empirical logit for the (transformed) fixations on the target (picture) and competitor (chair) during an anticipatory region ('about how the'):

```
m.elog <- lmer(elog ~ (ot1+ot2)*condition + (ot1+ot2 | by) +
(ot1+ot2 | by:condition),data=df2, weights=1/wts, REML=FALSE)
```

Appendix C

Appendix C.1. Sentential Stimuli used in Experiment 3

There were 4 versions of each discourse for each experimental item, varying the shift and foregrounding conditions orthogonally. In all items here, sentence ‘ii’ describes the movement of the protagonist, establishing whether or not the protagonist (i.e. the second-mentioned character) makes a shift to or from a location, and establishing whether the protagonist is in the same location as the target when mentioned in sentence ‘iii’. Thus, sentence ‘ii’ established the experimental conditions in all items. All items contain 4 versions of sentence ‘ii’ corresponding to the 4 conditions; however practice items contain 1 version of each condition, totalling two no-shift and two shift conditions that vary foregrounding across the items.

Sentence ‘i’ in the practice and experimental items describes a character (unique across all items), placing 4 objects in 2 locations in pairs. In these items the verb phrase is repeated 8 times across experimental items, but is unique in practice items. All objects and locations are unique across all items. Sentence ‘ii’ describes the protagonist (repeated twice across experimental items; unique amongst practice items) moving around one location or to/from one location to another. The verb phrase describing the movement of the protagonist is repeated 8 times across the experimental items, but is unique in practice items. All items describing the protagonist staying in one location use the verb phrase ‘…walk around’, but when the protagonist makes a spatial shift, half of the items describe this shift to (i.e. ‘…walk to’) another location, and half describe this shift from (i.e. ‘…walk from’) another location. Sentence ‘iii’ describes the protagonist thinking about the target. This verb phrase is repeated 4 times across experimental items, but is unique amongst practice items. The order of mention for the target is balanced to be either the first, second, third, or fourth mentioned objects in sentence ‘i’ across all items. Finally, a post-noun phrase follows the mention of the target and is unique across all items. All items take the form of the given example:

i. The boy has put the <u>*skateboard*</u> and the key in the **cafeteria**, and the ball and the melon in the parlour.

iia. His sister will *walk around* the **cafeteria** next to the parlour.
iib. His sister will *walk around* the parlour next to the **cafeteria**.
iic. His sister will *walk from* the parlour to the **cafeteria**.
iid. His sister will *walk from* the **cafeteria** to the parlour.

iii. Then she will think about how the *skateboard* is quite steady.

The underlined and italicised noun (e.g. *skateboard*) corresponds to the target object. The bold noun corresponds to the location of the target (e.g. **cafeteria**). The italicised phrase corresponds to the movement of the protagonist, establishing the four conditions: within sentence 'ii', 'a' corresponds to the no-shift and foregrounded condition, 'b' corresponds to the no-shift and backgrounded condition, 'c' corresponds to the shift and foregrounded condition, and 'd' corresponds to the shift and backgrounded condition. Finally, reference is made back to the target object (e.g. *skateboard*). A post noun phrase follows to complete the narrative, to allow for observation of any post-noun fixations (e.g. '…*is quite steady*').

No filler items were used in this experiment. However, the practice items took the same form as the experimental items. In these items, one of each condition was used, involving the shift and backgrounding conditions and the shift and foregrounding conditions. These items involved movement of the protagonist to and from one location to another respectively.

Appendix C.1.1. Experimental Sentences

1i. The boy has put the skateboard and the key in the cafeteria, and the ball and the melon in the parlour.

iia. His sister will walk around the cafeteria next to the parlour.

iib. His sister will walk around the parlour next to the cafeteria.

iic. His sister will walk from the parlour to the cafeteria.

iid. His sister will walk from the cafeteria to the parlour.

iii. Then she will think about how the skateboard is quite steady.

2i. The girl has laid the stapler and the racket in the resort, and the bagpipes and the kettle in the farm.

iia. Her brother will stroll around the resort next to the farm.

iib. Her brother will stroll around the farm next to the resort.

iic. Her brother will stroll from the farm to the resort.

iid. Her brother will stroll from the resort to the farm.

iii. Then he will remember that the stapler is relatively cheap.

3i. The nanny has moved the sausage and the plug into the lounge, and the necklace and the map into the high street.

iia. Her nephew will jog around the lounge next to the high street.

iib. Her nephew will jog around the high street next to the lounge.

iic. Her nephew will jog from the high street to the lounge.

iid. Her nephew will jog from the lounge to the high street.

iii. Then he will ponder over how the sausage is very tasty.

4i. The doctor has relocated the razor and the bike into the playroom, and the cigarette and the porridge into the student's union.

iia. Her father will wander around the playroom next to the student's union.

iib. Her father will wander around the student's union next to the playroom.

iic. Her father will wander from the student's union to the playroom.

iid. Her father will wander from the playroom to the student's union.

iii. Then he will recall that the razor is mostly sharp.

5i. The policeman has shifted the drill and the grapes into the base, and the paint and the coin into the field.

iia. His grandmother will dawdle around the base next to the field.

iib. His grandmother will dawdle around the field next to the base.

iic. His grandmother will dawdle from the field to the base.

iid. His grandmother will dawdle from the base to the field.

iii. Then she will deliberate over how the drill is exceptionally constructed.

6i. The florist has placed the battery and the cake in the street, and the glove and the accordion in the kitchen.

iia. Her grandfather will rush around the street next to the kitchen.

iib. Her grandfather will rush around the kitchen next to the street.

iic. Her grandfather will rush from the kitchen to the street.

iid. Her grandfather will rush from the street to the kitchen.

iii. Then he will reflect over how the battery is notably long-lasting.

7i. The workman has put the envelope and the trumpet in the bar, and the carrot and the lantern in the gallery.

iia. His girlfriend will wander around the bar next to the gallery.

iib. His girlfriend will wander around the gallery next to the bar.

iic. His girlfriend will wander from the gallery to the bar.

iid. His girlfriend will wander from the bar to the gallery.

iii. Then she will consider whether the trumpet is truly antique.

8i. The author has laid the bat and the table in the porch, and the dumbbell and the poncho in the yard.

iia. Her boyfriend will stroll around the porch next to the yard.

iib. Her boyfriend will stroll around the yard next to the porch.

iic. Her boyfriend will stroll from the yard to the porch.

iid. Her boyfriend will stroll from the porch to the yard.

iii. Then he will wonder whether the table is really wooden.

9i. The lifeguard has moved the violin and the coconut into the hallway, and the rug and the lighter into the ticket office.

iia. His auntie will walk around the hallway next to the ticket office.

iib. His auntie will walk around the ticket office next to the hallway.

iic. His auntie will walk from the ticket office to the hallway.

iid. His auntie will walk from the hallway to the ticket office.

iii. Then she will dwell over how the coconut is absolutely delicious.

10i. The lady has relocated the cheese and the glue into the front room, and the dart and the vest into the workshop.

iia. Her uncle will rush around the front room next to the workshop.

iib. Her uncle will rush around the workshop next to the front room.

iic. Her uncle will rush from the workshop to the front room.

iid. Her uncle will rush from the front room to the workshop.

iii. Then he will presume that the glue is awfully sticky.

11i. The landlord has shifted the piano and the bowl into the hairdressers, and the cutters and the doorstop into the recording studio.

iia. His niece will jog around the hairdressers next to the recording studio.

iib. His niece will jog around the recording studio next to the hairdressers.

iic. His niece will jog from the recording studio to the hairdressers.

iid. His niece will jog from the hairdressers to the recording studio.

iii. Then she will suppose that the bowl is uncommonly heavy.

12i. The teenager has put the potato and the nail in the warehouse, and the snorkel and the couch in the spa.

iia. His mother will dawdle around the warehouse next to the spa.

iib. His mother will dawdle around the spa next to the warehouse.

iic. His mother will dawdle from the spa to the warehouse.

iid. His mother will dawdle from the warehouse to the spa.

iii. Then she will realise that the nail is uncommonly expensive.

13i. The mechanic has placed the shirt and the butter in the restaurant, and the medicine and the cork in the arcade.

iia. His sister-in-law will stroll around the restaurant next to the arcade.

iib. His sister-in-law will stroll around the arcade next to the restaurant.

iic. His sister-in-law will stroll to the restaurant from the arcade.

iid. His sister-in-law will stroll to the arcade from the restaurant.

iii. Then she will realise that the shirt is considerably well-made.

14i. The accountant has laid the muffin and the trousers in the nursery, and the computer and the flower in the lodge.

iia. Her brother-in-law will wander around the nursery next to the lodge.

iib. Her brother-in-law will wander around the lodge next to the nursery.

iic. Her brother-in-law will wander to the nursery from the lodge.

iid. Her brother-in-law will wander to the lodge from the nursery.

iii. Then he will suppose that the muffin is notably appetising.

15i. The student has moved the hammer and the celery into the club house, and the lipstick and the notepad into the garden.

iia. His stepsister will rush around the club house next to the garden.

iib. His stepsister will rush around the garden next to the club house.

iic. His stepsister will rush to the club house from the garden.

iid. His stepsister will rush to the garden from the club house.

iii. Then she will presume that the hammer is very weighty.

16i. The attendant has relocated the camera and the jar into the reception, and the acorn and the postcard into the library.

iia. Her stepbrother will jog around the reception next to the library.

iib. Her stepbrother will jog around the library next to the reception.

iic. Her stepbrother will jog to the reception from the library.

iid. Her stepbrother will jog to the library from the reception.

iii. Then he will dwell over how the camera is absolutely shoddy.

17i. The architect has shifted the ashtray and the nut into the computer shop, and the surfboard and the badge into the city centre.

iia. His wife will walk around the computer shop next to the city centre.

iib. His wife will walk around the city centre next to the computer shop.

iic. His wife will walk to the computer shop from the city centre.

iid. His wife will walk to the city centre from the computer shop.

iii. Then she will wonder whether the ashtray is truly shatter-proof.

18i. The artist has placed the oar and the milk in the foyer, and the torch and the sock in the teacher's lounge.

iia. Her husband will dawdle around the foyer next to the teacher's lounge.

iib. Her husband will dawdle around the teacher's lounge next to the foyer.

iic. Her husband will dawdle to the foyer from the teacher's lounge.

iid. Her husband will dawdle to the teacher's lounge from the foyer.

iii. Then he will consider whether the oar is really lightweight.

19i. The carpenter has put the lock and the spoon in the rugby club, and the book and the plant in the airport.

iia. His ex-girlfriend will dawdle around the rugby club next to the airport.

iib. His ex-girlfriend will dawdle around the airport next to the rugby club.

iic. His ex-girlfriend will dawdle to the rugby club from the airport.

iid. His ex-girlfriend will dawdle to the airport from the rugby club.

iii. Then she will reflect over how the spoon is quite light.

20i. The paramedic has laid the calculator and the drum in the meadow, and the pumpkin and the sandal in the grounds.

iia. Her ex-boyfriend will stroll around the meadow next to the grounds.

iib. Her ex-boyfriend will stroll around the grounds next to the meadow.

iic. Her ex-boyfriend will stroll to the meadow from the grounds.

iid. Her ex-boyfriend will stroll to the grounds from the meadow.

iii. Then he will deliberate over how the drum is mostly inaudible.

21i. The electrician has moved the underwear and the pan into the pub, and the compass and the speaker into the hotel.

iia. His ex-wife will jog around the pub next to the hotel.

iib. His ex-wife will jog around the hotel next to the pub.

iic. His ex-wife will jog to the pub from the hotel.

iid. His ex-wife will jog to the hotel from the pub.

iii. Then she will recall that the pan is truly non-stick.

22i. The shop-assistant has relocated the lettuce and the ink into the mine, and the feather and the spade into the car park.

iia. Her ex-husband will wander around the mine next to the car park.

iib. Her ex-husband will wander around the car park next to the mine.

iic. Her ex-husband will wander to the mine from the car park.

iid. Her ex-husband will wander to the car park from the mine.

iii. Then he will ponder over how the ink is exceptionally coloured.

23i. The boxer has shifted the comb and the brick into the craft room, and the handcuffs and the strawberry into the greenhouse.

iia. His fiancée will rush around the craft room next to the greenhouse.

iib. His fiancée will rush around the greenhouse next to the craft room.

iic. His fiancée will rush to the craft room from the greenhouse.

iid. His fiancée will rush to the greenhouse from the craft room.

iii. Then she will remember that the brick is relatively inexpensive.

24i. The teacher has placed the saxophone and the tomato in the waiting room, and the phone and the rope in the vault.

iia. Her fiancé will walk around the waiting room next to the vault.

iib. Her fiancé will walk around the vault next to the waiting room.

iic. Her fiancé will walk to the waiting room from the vault.

iid. Her fiancé will walk to the vault from the waiting room.

iii. Then he will think about how the tomato is awfully ripe.

25i. The delivery-man has put the sushi and the letter in the tavern, and the pancake and the cap in the shop.

iia. His sister will rush around the shop next to the tavern.

iib. His sister will rush around the tavern next to the shop.

iic. His sister will rush from the tavern to the shop.

iid. His sister will rush from the shop to the tavern.

iii. Then she will think about how the pancake is notably tempting.

26i. The athlete has laid the matches and the tiara in the changing room, and the cereal and the wheel in the stables.

iia. Her brother will wander around the stables next to the changing room.

iib. Her brother will wander around the changing room next to the stables.

iic. Her brother will wander from the changing room to the stables.

iid. Her brother will wander from the stables to the changing room.

iii. Then he will remember that the cereal is very crunchy.

27i. The scientist has moved the banana and the trophy into the stock room, and the pipe and the mouse into the gymnasium.

iia. His mother will jog around the gymnasium next to the stock room.

iib. His mother will jog around the stock room next to the gymnasium.

iic. His mother will jog from the stock room to the gymnasium.

iid. His mother will jog from the gymnasium to the stock room.

iii. Then she will ponder over how the pipe is uncommonly designed.

28i. The model has relocated the trowel and the bread into the classroom, and the toothpaste and the headphones into the off-license.

iia. Her father will walk around the off-license next to the classroom.

iib. Her father will walk around the classroom next to the off-license.

iic. Her father will walk from the classroom to the off-license.

iid. Her father will walk from the off-license to the classroom.

iii. Then he will recall that the toothpaste is awfully minty.

29i. The engineer has shifted the beer and the film into the taxi rank, and the hat and the quiche into the coffee shop.

iia. His grandmother will dawdle around the coffee shop next to the taxi rank.

iib. His grandmother will dawdle around the taxi rank next to the coffee shop.

iic. His grandmother will dawdle from the taxi rank to the coffee shop.

iid. His grandmother will dawdle from the coffee shop to the taxi rank.

iii. Then she will deliberate over how the hat is relatively fashionable.

30i. The biologist has put the boat and the newspaper in the factory, and the clarinet and the pineapple in the theatre.

iia. Her grandfather will stroll around the theatre next to the factory.

iib. Her grandfather will stroll around the factory next to the theatre.

iic. Her grandfather will stroll from the factory to the theatre.

iid. Her grandfather will stroll from the theatre to the factory.

iii. Then he will reflect over how the clarinet is quite beautiful.

31i. The mayor has placed the pear and the whisky in the museum, and the handbag and the stopwatch in the lobby.

iia. His girlfriend will rush around the lobby next to the museum.

iib. His girlfriend will rush around the museum next to the lobby.

iic. His girlfriend will rush from the museum to the lobby.

iid. His girlfriend will rush from the lobby to the museum.

iii. Then she will consider whether the stopwatch is really fast.

32i. The police officer has laid the toast and the bullet in the tourist office, and the cactus and the ruler in the cathedral.

iia. Her boyfriend will jog around the cathedral next to the tourist office.

iib. Her boyfriend will jog around the tourist office next to the cathedral.

iic. Her boyfriend will jog from the tourist office to the cathedral.

iid. Her boyfriend will jog from the cathedral to the tourist office.

iii. Then he will wonder whether the ruler is mostly accurate.

33i. The chemist has moved the chocolate and the belt into the surf shop, and the monitor and the painting into the box office.

iia. His auntie will stroll around the box office next to the surf shop.

iib. His auntie will stroll around the surf shop next to the box office.

iic. His auntie will stroll from the surf shop to the box office.

iid. His auntie will stroll from the box office to the surf shop.

iii. Then she will dwell over how the painting is exceptionally crafted.

34i. The lawyer has relocated the candle and the jeans into the driveway, and the noodles and the stamp into the stadium.

iia. Her uncle will wander around the stadium next to the driveway.

iib. Her uncle will wander around the driveway next to the stadium.

iic. Her uncle will wander from the driveway to the stadium.

iid. Her uncle will wander from the stadium to the driveway.

iii. Then he will presume that the stamp is considerably rare.

35i. The greengrocer has shifted the pillow and the cocktail into the supermarket, and the shovel and the football into the backyard.

iia. His niece will walk around the backyard next to the supermarket.

iib. His niece will walk around the supermarket next to the backyard.

iic. His niece will walk from the supermarket to the backyard.

iid. His niece will walk from the backyard to the supermarket.

iii. Then she will suppose that the football is quite inflated.

36i. The instructor has placed the syringe and the fork in the guard tower, and the rucksack and the gramophone in the security office.

iia. Her nephew will dawdle around the security office next to the guard tower.

iib. Her nephew will dawdle around the guard tower next to the security office.

iic. Her nephew will dawdle from the guard tower to the security office.

iid. Her nephew will dawdle from the security office to the guard tower.

iii. Then he will realise that the gramophone is absolutely broken.

37i. The decorator has put the blanket and the handbook in the playground, and the leaf and the steak in the buffet.

iia. His sister-in-law will jog around the buffet next to the playground.

iib. His sister-in-law will jog around the playground next to the buffet.

iic. His sister-in-law will jog to the buffet from the playground.

iid. His sister-in-law will jog to the playground from the buffet.

iii. Then she will realise that the leaf is very green.

38i. The librarian has laid the mirror and the knife in the cottage, and the clock and the slingshot in the corner shop.

iia. Her brother-in-law will rush around the corner shop next to the cottage.

iib. Her brother-in-law will rush around the cottage next to the corner shop.

iic. Her brother-in-law will rush to the corner shop from the cottage.

iid. Her brother-in-law will rush to the cottage from the corner shop.

iii. Then he will suppose that the clock is considerably slow.

39i. The builder has moved the rivet and the blouse into the outlet store, and the megaphone and the hotdog into the fair.

iia. His stepsister will dawdle around the fair next to the outlet store.

iib. His stepsister will dawdle around the outlet store next to the fair.

iic. His stepsister will dawdle to the fair from the outlet store.

iid. His stepsister will dawdle to the outlet store from the fair.

iii. Then she will presume that the megaphone is considerably loud.

40i. The dancer has relocated the coat and the salad into the mall, and the mace and the yo-yo into the corridor.

iia. Her stepbrother will wander around the corridor next to the mall.

iib. Her stepbrother will wander around the mall next to the corridor.

iic. Her stepbrother will wander to the corridor from the mall.

iid. Her stepbrother will wander to the mall from the corridor.

iii. Then he will dwell over how the mace is awfully hefty.

41i. The comedian has shifted the whistle and the ketchup into the arena, and the teapot and the pliers into the dressing room.

iia. His wife will walk around the dressing room next to the arena.

iib. His wife will walk around the arena next to the dressing room.

iic. His wife will walk to the dressing room from the arena.

iid. His wife will walk to the arena from the dressing room.

iii. Then she will wonder whether the teapot is notably chipped.

42i. The Duchess has placed the wine and the crown in the pharmacy, and the jelly and the umbrella in the campus.

iia. Her husband will stroll around the campus next to the pharmacy.

iib. Her husband will stroll around the pharmacy next to the campus.

iic. Her husband will stroll to the campus from the pharmacy.

iid. Her husband will stroll to the pharmacy from the campus.

iii. Then he will consider whether the jelly is really wobbly.

43i. The politician has put the wallet and the cardboard in the drawing room, and the tart and the mitten in the tennis courts.

iia. His ex-girlfriend will walk around the tennis courts next to the drawing room.

iib. His ex-girlfriend will walk around the drawing room next to the tennis courts.

iic. His ex-girlfriend will walk to the tennis courts from the drawing room.

iid. His ex-girlfriend will walk to the drawing room from the tennis courts.

iii. Then she will reflect over how the mitten is uncommonly knitted.

44i. The veterinarian has laid the typewriter and the saucepan in the charity shop, and the mascara and the beanbag in the mansion.

iia. Her ex-boyfriend will rush around the mansion next to the charity shop.

iib. Her ex-boyfriend will rush around the charity shop next to the mansion.

iic. Her ex-boyfriend will rush to the mansion from the charity shop.

iid. Her ex-boyfriend will rush to the charity shop from the mansion.

iii. Then he will deliberate over how the beanbag is mostly comfortable.

45i. The novelist has moved the soap and the chisel into the toilets, and the mug and the dice into the staff room.

iia. His ex-wife will dawdle around the staff room next to the toilets.

iib. His ex-wife will dawdle around the toilets next to the staff room.

iic. His ex-wife will dawdle to the staff room from the toilets.

iid. His ex-wife will dawdle to the toilets from the staff room.

iii. Then she will recall that the dice is truly fair.

46i. The musician has relocated the crutch and the bacon into the school, and the wand and the stone into the basement.

iia. Her ex-husband will wander around the basement next to the school.

iib. Her ex-husband will wander around the school next to the basement.

iic. Her ex-husband will wander to the basement from the school.

iid. Her ex-husband will wander to the school from the basement.

iii. Then he will ponder over how the stone is absolutely worthless.

47i. The poet has shifted the sandwich and the monocle into the food hall, and the bandage and the guitar into the show room.

iia. His fiancée will jog around the show room next to the food hall.

iib. His fiancée will jog around the food hall next to the show room.

iic. His fiancée will jog to the show room from the food hall.

iid. His fiancée will jog to the food hall from the show room.

iii. Then she will remember that the guitar is exceptionally made.

48i. The dentist has placed the paintbrush and the headband in the observatory, and the spaghetti and the bell in the exercise yard.

iia. Her fiancé will stroll around the exercise yard next to the observatory.

iib. Her fiancé will stroll around the observatory next to the exercise yard.

iic. Her fiancé will stroll to the exercise yard from the observatory.

iid. Her fiancé will stroll to the observatory from the exercise yard.

iii. Then he will think about how the bell is relatively quiet.

Appendix C.1.2. Practice Sentences

49i. The social worker has brought the bottle and the chips to the boulevard, and the kite and the floss to the town square.

ii. His friend will hobble around the boulevard next to the town square.

iii. Then she will wish that the bottle is totally full.

50i. The editor has planted the armour and the pot in the bank, and the earring and the swimsuit in the laboratory.

ii. Her colleague will saunter around the laboratory next to the bank.

iii. Then he will contemplate whether the pot is genuinely dirty.

51i. The director has transferred the corn and the tie to the auditorium, and the microscope and the plunger to the quarry.

ii. His workmate will go from the auditorium to the quarry.

iii. Then she will believe that the microscope is severely fragile.

52i. The geologist has sent the desk and the magazine to the ice-rink, and the biscuit and the cape to the common room.

ii. Her assistant will amble to the ice-rink from the common room.

iii. Then he will question whether the cape is utterly useless.

Appendix C.2. Visual Stimuli used in Experiment 3

All visual stimuli displayed here are scaled down from the original 800 x 600 pixels. Visual stimuli were displayed with a 200 pixel grey border around the perimeter. All stimuli below have an added black border for ease of viewing due to the use of a white background; however this was not included in the experiment due to the inclusion of the 200 pixel grey border.

Appendix C.2.1. Experimental Scenes

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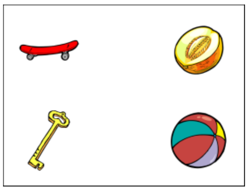
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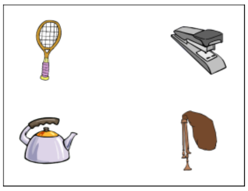
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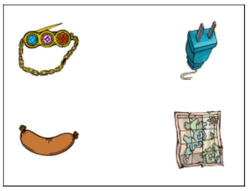
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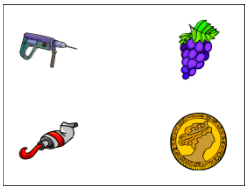
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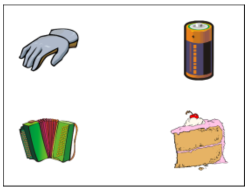
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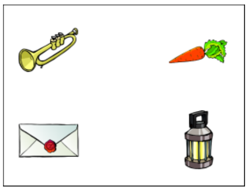
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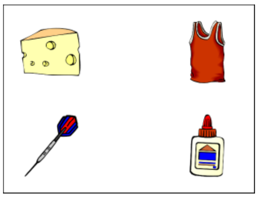
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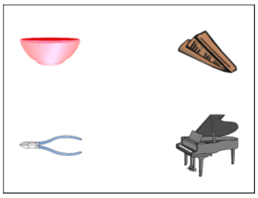
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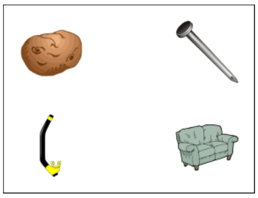
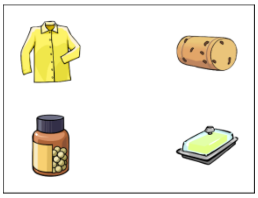
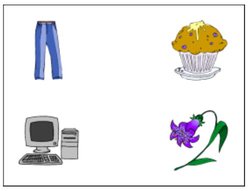
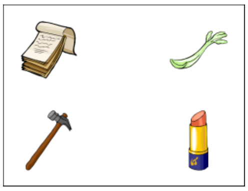


13. 

14. 

15. 

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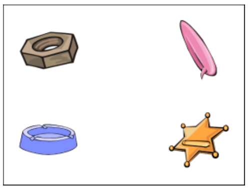
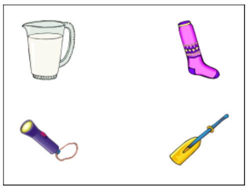
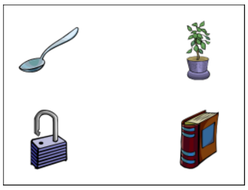
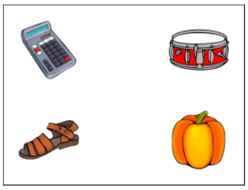
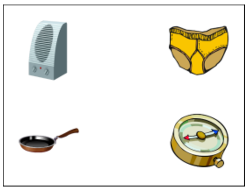
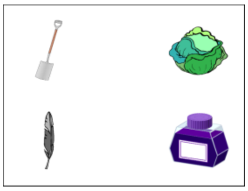
17. 

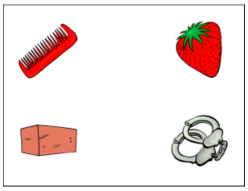
18. 

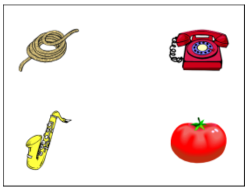
19. 

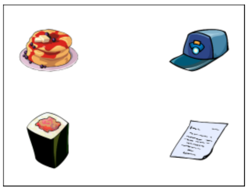
20. 

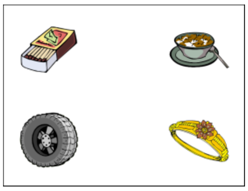
21. 

22. 

23. 

24. 

25. 

26. 

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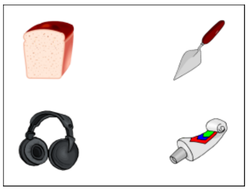
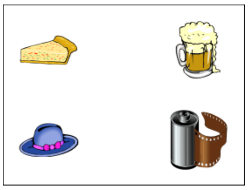
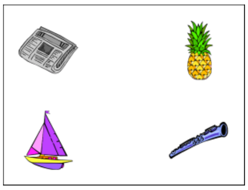
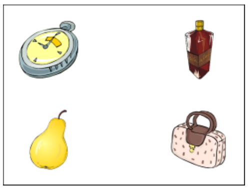
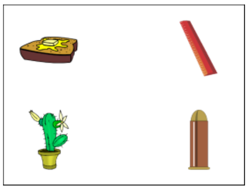
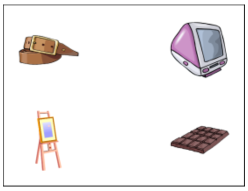
28. 

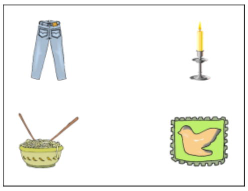
29. 

30. 

31. 

32. 

33. 

34. 

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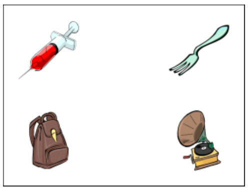
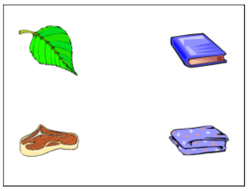
36. 

37. 

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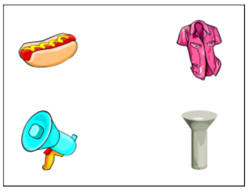
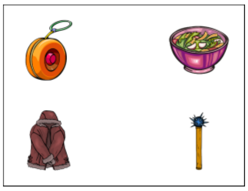
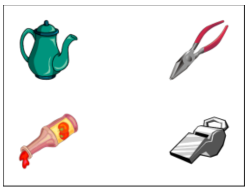
39. 

40. 

41. 

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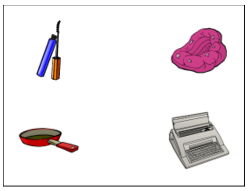
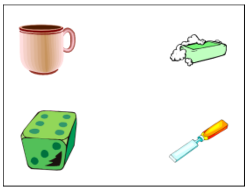
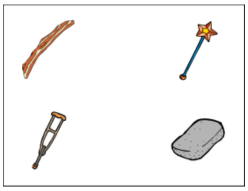
43. 

44. 

45. 

46. 

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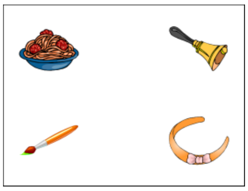
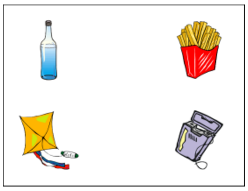
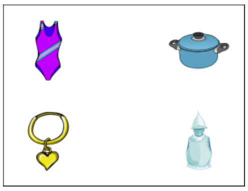
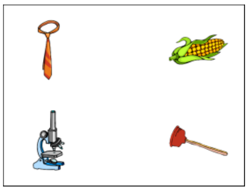
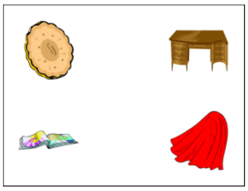
48. 

Appendix C.2.2. Practice Scenes

49. 

50. 

51. 

52. 

Appendix C.3. Deviation Coding for Factors in Experiment 3

In order to obtain main effects of each factor with two levels each (Shifts: No-shift, Shift; Foregrounding: Backgrounded, Foregrounded) deviation coding was used such that the baseline (0) for the model represented the grand mean of both factors, and the baseline for each factor was the average of both levels. Deviation coding was computed as follows, creating a new numerical variable from the original treatment coded factors:

```
dt2$S <- ifelse(dt2$shifts=="no_shift",-.5,.5)

dt2$For <- ifelse(dt2$foregrounding=="backgrounded",-.5,.5)
```

Appendix C.4. Models for Analysis during both time windows in Experiment 3

Appendix C.4.1. Calculating the empirical logit for the (transformed) fixations on the target (skateboard) during the critical noun ('skateboard):

For both by-participants and by-items analyses, fixations were transformed using the empirical logit (`elog`), using a similar method outlined in Appendix A.3. Both models contain fixed effects of the two deviation coded factors reflecting the two conditions, Shifts (`S`) and Foregrounding (`For`), as well as fixed effects of time; using linear orthogonal polynomials (`ot1`). Both models contain maximal random effects structures (and their correlations) of participants/items (`by`) and participants/items by Foregrounding and Shifts (`by: For: S`) for the linear orthogonal time term. The 'by' factor took on the properties of participants/items depending upon the analysis used; hence the model structure is the same across both analyses even if its contents differ. In both, weights were calculated in a similar manner outlined in Appendix A.3. Here, *p*-values were calculated in the manner outlined in Appendix C.5.

```
m.elog <- lmer(elog ~ ot1*S*For + (ot1 | by) + (ot1 | by: S: For),data=df2,
weights=1/wts, REML=FALSE)
```

Appendix C.4.2. Calculating the empirical logit for the (transformed) fixations on the target (skateboard) during the the region prior to the noun (‘Then she will think about how’):

For both by-participants and by-items analyses, fixations were transformed using the empirical logit (`elog`), using a similar method outlined in Appendix A.3. Both models contain fixed effects the two conditions, Shifts and Foregrounding, on one factor, condition (`condition`), as well as fixed effects of time; using linear orthogonal polynomials (`ot1`). Both models contain maximal random effects structures (and their correlations) of participants/items (`by`) and participants/items by condition (`by: condition`) for the linear orthogonal time term. The ‘by’ factor took on the properties of participants/items depending upon the analysis used; hence the model structure is the same across both analyses even if its contents differ. In both, weights were calculated in a similar manner outlined in Appendix A.3. Here, *p*-values were calculated in the manner outlined in Appendix A.4.

```
m.elog <- lmer(elog ~ ot1*condition + (ot1 | by) +
(ot1 | by:condition),data=df2, weights=1/wts, REML=FALSE)
```

Appendix C.5. Calculating *p*-values using the normal approximation

Statistical significance for individual parameter estimates was calculated using the normal approximation. This approach was used instead of the method outlined in Section 0 as each factor only contained at most two levels (cf. models used in the region prior to the noun in Experiment 3). As such, multiple comparisons were not required. Following the approach outlined in Mirman (2014), the parameter estimates from each model were transformed into a new data frame, with fixed effect parameter estimates extracted from the summary of the model using the `coefs` function:

```
coefs <- data.frame(coef(summary(m.elog)))
```

The *p*-values were then obtained by looking up the *p*-value corresponding to the value of the t-value in the normal distribution using the `pnorm` function, and then subtracting this value from 1 to obtain the probability of obtaining a t-value exceeding the observed value, multiplying this value by 2 to obtain a two-tailed *p*-value, and then assigning this value to a new variable (`p`) in the `coefs` data frame.

```
coefs$p <- 2*(1-pnorm(abs(coefs$t.value)))
```

Then, the fixed effect parameter estimates and their p-values were retrieved by recalling the `coefs` data frame, rounding up values to 3 decimal places:

```
print(round(coefs,3))
```

Appendix D

Appendix D.1. Sentential Stimuli used in Experiments 4 and 5

There was 1 version of each discourse for each experimental item. However, two pairs of visual scenes depicted the two conditions, as outlined in Section Appendix D.2.

Sentence ‘i’ in the practice, experimental, and filler items describes a protagonist (unique across all items), moving an object to a new location. The named object and destination were unique across all items; however variations on the same type of object were included but unmentioned in other items. The verb phrase (e.g. ‘take’) was repeated four times across experimental and filler items, but was unique amongst practice items. Sentence ‘ii’ describes the protagonist – by use of a pronoun (e.g. ‘she’) – looking towards another object in the same room as the final location of the moved object before interacting with the moved object. The protagonist was balanced across all items to include an equal number of male and female nouns and pronouns in sentences ‘i’ and ‘ii’. The object mentioned prior to the protagonist interacting with the moved object was unique across all items; again, variations on the same type of object were included but unmentioned in other items. All items take the form of the given example:

i. The woman will take the <u>*book*</u> to the table.

  ii. Then she will study the <u>picture</u> and read the <u>*book*</u>.

The underlined and italicised noun (e.g. <u>*book*</u>) corresponds to the target object, and the underlined noun (e.g. <u>picture</u>) corresponds to the mentioned distractor object. Filler and practice sentences took the same form as the experimental sentences; however they varied from the experimental sentences in the form of the visual scenes. For the filler sentences, half of the items referred to an unmoved object as the discourse-final noun. As such, Section Appendix D.2 outlines the differences across these items and the measures taken during counterbalancing.

Appendix D.1.1. Experimental Sentences

1i. The woman will take the book to the table.

  ii. Then she will study the picture and read the book.

2i. The man will move the shoes into the box.

  ii. Then he will spot the dumbbell and clean the shoes.

3i. The nanny will put the cap onto the teddy.

ii. Then she will admire the rug and brush the cap.

4i. The boxer will place the keys on the water cooler.

ii. Then he will look at the boxing gloves and pick up the keys.

5i. The librarian will lay the calculator on the filing cabinet.

ii. Then she will check the microscope and wipe the calculator.

6i. The landlord will set the spoon on the stool.

ii. Then he will watch the dart board and polish the spoon.

7i. The dancer will rest the briefcase on the decks.

ii. Then she will locate the spanner and open the briefcase.

8i. The decorator will transfer the purse to the ladder.

ii. Then he will see the paint and inspect the purse.

9i. The wife will relocate the wallet onto the trolley.

ii. Then she will notice the teacup and clasp the wallet.

10i. The greengrocer will bring the screwdriver to the paper bag.

ii. Then he will stare at the magnifying glass and handle the screwdriver.

11i. The father will take the dustpan to the desk.

ii. Then he will see the painting and clutch the dustpan.

12i. The instructor will move the tissues into the basket.

ii. Then she will spot the boot and grab the tissues.

13i. The businessman will put the medicine bottle into the suitcase.

ii. Then he will notice the umbrella and tighten the medicine bottle.

14i. The fireman will lay the drill on the bench.

ii. Then he will check the hat and grip the drill.

15i. The cleaner will place the sandwich into the bag.

ii. Then she will stare at the vacuum cleaner and eat the sandwich.

16i. The poet will set the teapot on the footstool.

ii. Then she will admire the electric guitar and grasp the teapot.

17i. The lecturer will rest the guitar on the bed.

ii. Then she will look at the flowers and play the guitar.

18i. The teacher will transfer the birthday cake to the scales.

ii. Then he will study the lamp and cut the birthday cake.

19i. The doctor will relocate the wine onto the bar.

ii. Then he will watch the gloves and sip the wine.

20i. The Duchess will bring the candle to the books.

ii. Then she will locate the shelf and blow out the candle.

Appendix D.1.2. Filler Sentences

21i. The secretary will take the ice-cream to the pillow.

ii. Then she will admire the portrait and flatten the pillow.

22i. The student will move the satchel onto the bedside table.

ii. Then she will spot the drink and close the journal.

23i. The politician will put the towels on the coat hanger.

ii. Then he will notice the pepper grinder and arrange the coat hanger.

24i. The banker will place the laundry basket on the mat.

ii. Then he will look at the plant and tidy the laundry basket.

25i. The novelist will lay the popcorn on the safe.

ii. Then she will study the trumpet and devour the popcorn.

26i. The nanny will set the newspaper on the turntable.

ii. Then she will watch the skipping rope and roll up the newspaper.

27i. The musician will rest the hockey stick on the dishwasher.

ii. Then he will locate the cards and start the dishwasher.

28i. The comedian will transfer the trophy to the cupboard.

ii. Then he will check the matches and unlock the lunchbox.

29i. The boy will relocate the note to the plate.

ii. Then he will see the skate and crease the note.

30i. The girl will bring the crayons to the cot.

ii. Then she will stare at the gravy boat and organise the crayons.

31i. The grandfather will take the sandal to the sofa.

ii. Then he will see the light and taste the pint.

32i. The grandmother will move the sleeping bag into the drawers.

ii. Then she will spot the rattle and rearrange the sleeping bag.

33i. The dentist will put the walkie-talkie on the fireplace.

ii. Then she will look at the dummy and fix the walkie-talkie.

34i. The florist will lay the sacks into the cart.

ii. Then she will stare at the hammer and sort the sacks.

35i. The maid will place the jacket into the washing machine.

ii. Then she will check the binoculars and shut the washing machine.

36i. The pilot will set the bread on the bin.

ii. Then he will study the toolbox and peel the banana.

37i. The surfer will rest the wrapping paper on the crate.

ii. Then he will locate the shears and fold the wrapping paper.

38i. The actor will transfer the stereo to the notepad.

ii. Then she will watch the cake and turn on the stereo.

39i. The gardener will relocate the pizza onto the tray.

ii. Then he will notice the muffin and lift the tray.

40i. The author will bring the sweets to the jar.

ii. Then he will admire the gramophone and switch on the beeper.

Appendix D.1.3. Practice Sentences

41i. The magician will shift the spray onto the couch.

ii. Then she will examine the razor and sit on the couch.

42i. The barman will plant the brush in the bucket.

ii. Then he will view the snow globe and pick the brush.

43i. The mayor will insert the pie into the pot.

ii. Then he will observe the carrots and smell the pie.

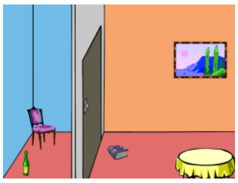
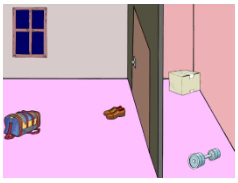
44i. The police officer will stuff the pop into the cooler box.

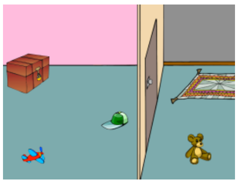
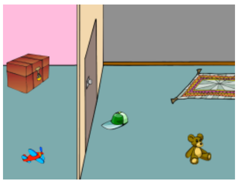
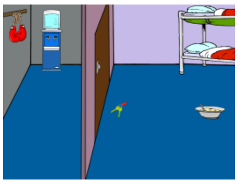
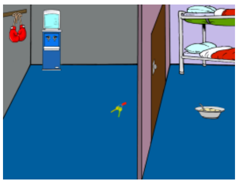
ii. Then she will detect the grapes and drink the pop.

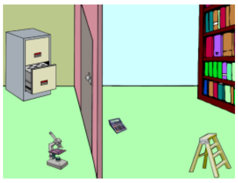
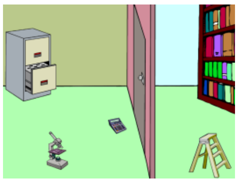
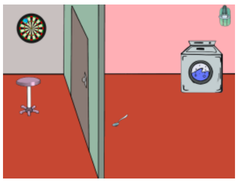
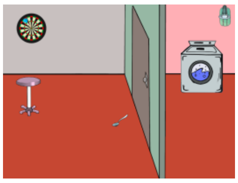
Appendix D.2. Visual Stimuli used in Experiment 4 and 5

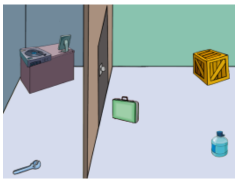
There were 2 versions of each visual scene for each experimental item, corresponding to the ‘Apart’ and ‘Together’ conditions, related to whether or not the source and goal location for the object were in the same or separate rooms respectively. For the pairs of images, those noted as ‘a’ depict the Apart condition, whereas those noted as ‘b’ depict the Together condition. In both conditions the target remained in the same location, centrally in the visual scene, however the boundary was placed to the left or right of this object. Across items the target varied in its placement on the *y*-axis, located at varying heights above and below the middle point of the visual scene. The described movement of the object to the goal occurred from left to right and from right to left an equal number of times across items. The goal location was also located in each corner of the visual scene an equal number of times. Each room in the visual scenes contained one possible goal location (e.g. a chair or a table on which the book could rest), and a possible distractor (e.g. a picture or bottle for the protagonist to look at) to reduce prediction for the goal of the target prior to mention. Filler items took the same form as the experimental items but the mentioned object was one not located in the centre of the visual scene. Furthermore, as noted in Section Appendix D.1, in half of the fillers the discourse-final noun did not refer to the moved object. The practice trials consisted of two experimental-type items and two filler-type items (of each type), varying the movement of the object equally from one room to another and within one room.

Appendix D.2.1. Experimental Scene Pairs

1a. 
1b. 
2a. 
2b. 

3a. 
3b. 
4a. 
4b. 

5a. 
5b. 
6a. 
6b. 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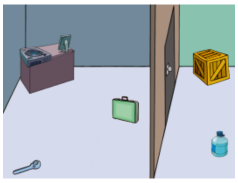
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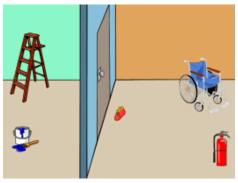
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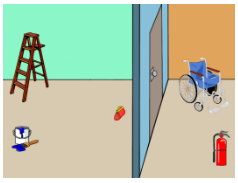
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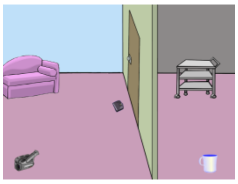
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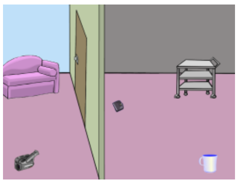
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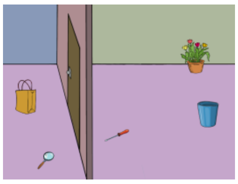
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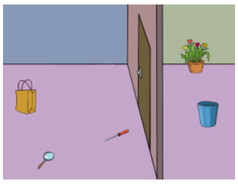
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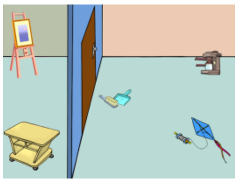
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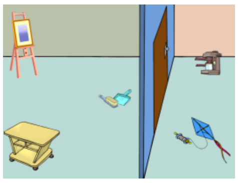
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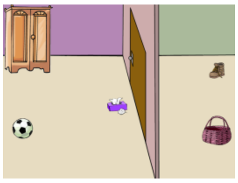
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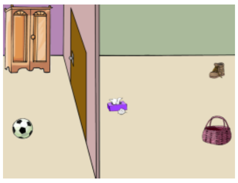
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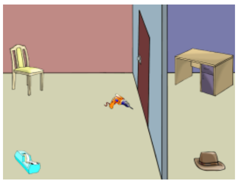
13a.


13b.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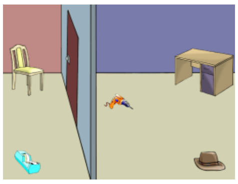
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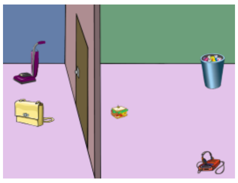
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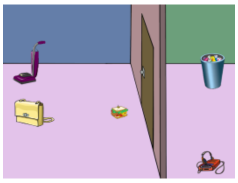
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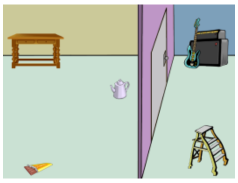
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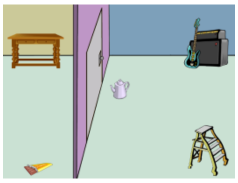
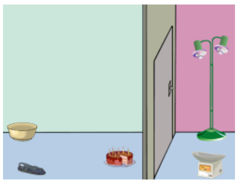

16b.


17a.


17b.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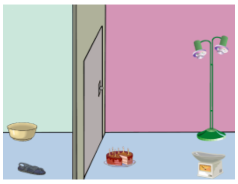
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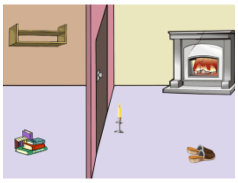
19a.


19b.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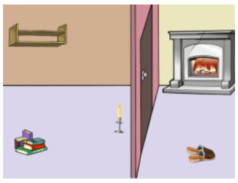
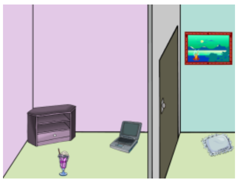

20b.

Appendix D.2.2. Filler Scenes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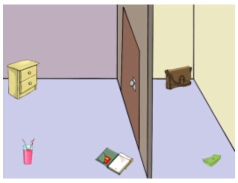
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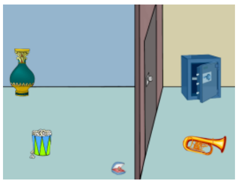
23.


24.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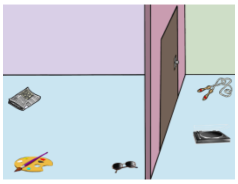
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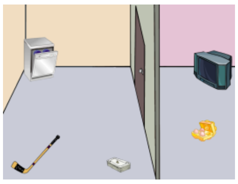
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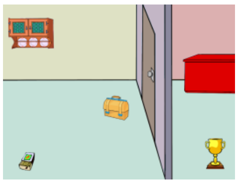
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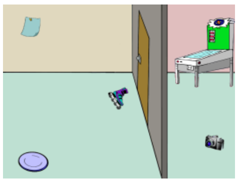
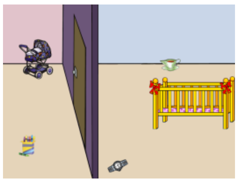
29. 
30. 
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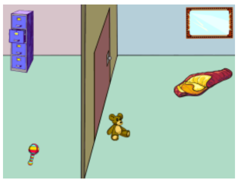
32. 
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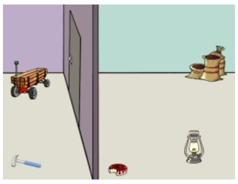
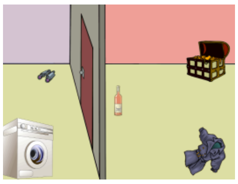
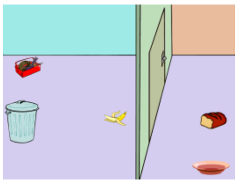
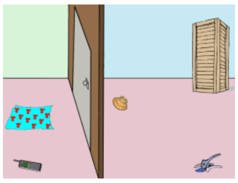
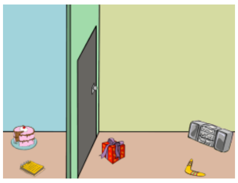
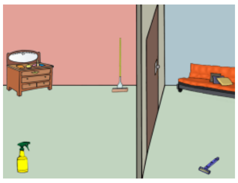
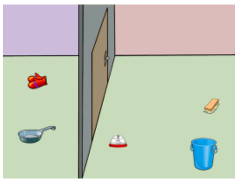
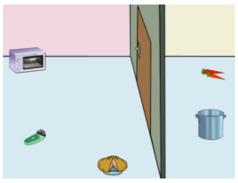
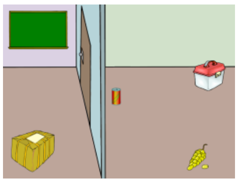
34. 
35. 
36. 
37. 
38. 
39. 
40. 

Appendix D.2.3. Practice Scenes

41. 
42. 
43. 
44. 

Appendix D.3. Models used for Analysis during the critical noun (‘book’) in Experiments 4 and 5

For both by-participants and by-items analyses, fixations were transformed using the empirical logit (`elog`), using a similar method outlined in Appendix A.3. Here, `elog` represented the proportion of fixations on the source, goal, or doorway depending on the analysis conducted. Both models contain fixed effects of condition (`condition`) and fixed effects of time; using linear (`ot1`) and quadratic (`ot2`) orthogonal polynomials. Departing from the method outlined in Appendix A.3, for the fixations on the source (book) across Experiments 4 and 5, and for the fixations on the doorway in experiment 4, the random effects structure was simplified to account for convergence failure in the model. To do so, random effects for participants/items were included for the intercept and both time terms (`ot1+ot2 | by:condition)`, and the random effects of participants/items nested within condition were included for the intercept (`1 | by:condition`), and for both time terms (`0 + ot1 | by:condition), (0 + ot2 | by:condition`); but the correlations amongst these random effects were removed. However, for fixations on the goal (table) no convergence failure was reported, as such the correlation between random effects was included in the model. Similarly to Appendix A.3, the ‘`by`’ factor took on the properties of participants/items depending upon the analysis used; hence the model structure is the same across both analyses even if its contents differ. In both, weights were calculated in a similar manner outlined in Appendix A.3. In all analyses, *p*-values were calculated in the manner outlined in Appendix C.5.

Appendix D.3.1. Experiments 4 and 5: Calculating the empirical logit for the (transformed) fixations on the source (book) during the critical noun (‘book’):

```
m.elog <- lmer(elog ~ (ot1+ot2)*condition + (ot1+ot2 | by) + (1 |
by:condition) + (0 + ot1 | by:condition)  + (0 + ot2 |
by:condition),data=df2, weights=1/wts, REML=FALSE)
```

Appendix D.3.2. Experiments 4 and 5: Calculating the empirical logit for the (transformed) fixations on the goal (table) during the critical noun (‘book’):

```
m.elog <- lmer(elog ~ (ot1+ot2)*condition + (ot1+ot2 | by) + (ot1+ot2 |
by:condition),data=df2, weights=1/wts, REML=FALSE)
```

Appendix D.3.3. Experiment 4: Calculating the empirical logit for the (transformed) fixations on the boundary (doorway) during the critical noun (‘book’):

```
m.elog <- lmer(elog ~ (ot1+ot2)*condition + (ot1+ot2 | by) + (1 |
by:condition) + (0 + ot1 | by:condition)  + (0 + ot2 |
by:condition),data=df2, weights=1/wts, REML=FALSE)
```

Appendix D.3.4. Experiment 5: Calculating the empirical logit for the (transformed) fixations on the boundary (doorway) during the critical noun (‘book’):

```
m.elog <- lmer(elog ~ (ot1+ot2)*condition + (ot1+ot2 | by) + (ot1+ot2 |
by:condition),data=df2, weights=1/wts, REML=FALSE)
```

Appendix E

Appendix E.1. Sentential Stimuli used in Experiment 6

There was 1 version of each discourse for each experimental item. However, two pairs of visual scenes depicted the two conditions, as outlined in Section Appendix E.2. The same restrictions used in the design of Experiments 4 and 5 were used here, however the discourse in sentence ‘i’ involves movement of an unseen object from one container to another. Here, the container names were unique amongst all items. In a departure from the design of the sentences in Experiments 4 and 5, sentence ‘ii’ also included an adverbial phrase prior to the onset of the discourse final noun. This phrase always included the adverb ‘very’ and rotated across another adverb, e.g. ‘quickly’, four times across all items. The adverbial phrase was unique for the practice items. Only experimental and practice items taking the same form as the experimental items were used in this experiment.

All items take the form of the given example:

i. The woman will move the *book* from the handbag into the folder.

ii. Then she will study the painting and then very slowly pick up the *book*.

The underlined and italicised noun (e.g. *book*) corresponds to the target object, and the underlined noun (e.g. picture) corresponds to the mentioned distractor object. Section Appendix E.2 outlines the differences across these items and the measures taken during counterbalancing.

Appendix E.1.1. Experimental Sentences

1i. The woman will move the book from the handbag into the folder.

ii. Then she will study the painting and then very slowly pick up the book.

2i. The man will place the shoes from the paper bag into the box.

ii. Then he will spot the dumbbell and then very hurriedly grasp the shoes.

3i. The nanny will shift the collar from the cage into the footlocker.

ii. Then she will admire the teddy and then very suddenly clasp the collar.

4i. The boxer will transfer the medicine from the tub into the fridge.

ii. Then he will look at the boxing gloves and then very quickly grab the medicine.

5i. The librarian will pass the calculator from the backpack into the filing cabinet.
    ii. Then she will check the microscope and then very calmly clutch the calculator.

6i. The landlord will relocate the cloth from the pan into the washing machine.
    ii. Then he will watch the dart board and then very lazily grip the cloth.

7i. The dancer will put the memory card from the briefcase into the decks.
    ii. Then she will locate the spanner and then very briefly clench the memory card.

8i. The wife will deposit the coin from the purse into the sweet box.
    ii. Then she will see the paint and then very rapidly seize the coin.

9i. The decorator will lay the money from the wallet into the cup.
    ii. Then he will notice the trolley and then very promptly snatch the money.

10i. The greengrocer will insert the screws from the beaker into the dust bin.
    ii. Then he will see the magnifying glass and then very carefully handle the screws.

11i. The father will move the sugar from the luggage into the coffee machine.
    ii. Then he will stare at the canvas and then very slowly pick up the sugar.

12i. The instructor will place the sweets from the jug into the basket.
    ii. Then she will spot the boot and then very suddenly clasp the sweets.

13i. The businessman will shift the tablets from the bottle into the suitcase.
    ii. Then he will notice the umbrella and then very hurriedly grab the tablets.

14i. The fireman will transfer the video game from the sack into the desk drawer.
    ii. Then he will check the hat and then very quickly clutch the video game.

15i. The cleaner will pass the sandwich from the picnic basket into the satchel.
    ii. Then she will look at the vacuum cleaner and then very briefly grasp the sandwich.

16i. The cook will relocate the pasta from the colander into the carrier bag.
    ii. Then she will admire the electric guitar and then very rapidly seize the pasta.

17i. The lecturer will lay the necklace from the jewellery box into the bed.

ii. Then she will stare at the flowers and then very calmly grip the necklace.

18i. The teacher will put the cake mix from the measuring jug into the scales.

ii. Then he will study the lamp and then very carefully handle the cake mix.

19i. The doctor will deposit the wine from the trunk into the bar.

ii. Then he will watch the gloves and then very promptly snatch the wine.

20i. The designer will insert the paper from the pencil case into the books.

ii. Then she will locate the shelf and then very lazily clench the paper.

21i. The secretary will move the cotton wool from the cardboard box into the rubbish bin.

ii. Then she will admire the portrait and then very slowly pick up the cotton wool.

22i. The student will place the cap from the hat box into the bedside cabinet.

ii. Then she will spot the drink and then very calmly handle the cap.

23i. The politician will shift the glass from the parcel into the ice bucket.

ii. Then he will notice the pepper grinder and then very suddenly clasp the glass.

24i. The banker will transfer the trainers from the gift box into the laundry basket.

ii. Then he will look at the plant and then very quickly grab the trainers.

25i. The novelist will deposit the cheque book from the lunch box into the safe.

ii. Then she will study the trumpet and then very hurriedly snatch the cheque book.

26i. The nanny will insert the batteries from the pot into the turntable.

ii. Then she will watch the skipping rope and then very briefly grasp the batteries.

27i. The boy will lay the flask from the travel bag into the dishwasher.

ii. Then he will stare at the hockey stick and then very lazily grip the flask.

28i. The comedian will relocate the drill from the toolbox into the cupboard.

ii. Then he will see the matches and then very promptly clench the drill.

29i. The musician will put the beer from the ice box into the jacket.

ii. Then he will locate the note and then very rapidly seize the beer.

30i. The girl will pass the dummy from the wagon into the cot.

ii. Then she will see the watch and then very carefully pick up the dummy.

31i. The grandfather will move the whisky from the barrel into the chest.

ii. Then he will check the light and then very slowly clutch the whisky.

32i. The grandmother will place the documents from the files into the drawers.

ii. Then she will spot the rattle and then very briefly clench the documents.

33i. The dentist will deposit the letter from the ledger into the lockbox.

ii. Then she will look at the walkie-talkie and then very hurriedly clasp the letter.

34i. The florist will transfer the potatoes from the wicker basket into the cart.

ii. Then she will stare at the hammer and then very quickly grab the potatoes.

35i. The maid will pass the scarf from the bag into the tumble dryer.

ii. Then she will check the binoculars and then very suddenly clutch the scarf.

36i. The pilot will put the love letter from the chocolate box into the bin.

ii. Then he will study the tools and then very calmly grasp the love letter.

37i. The surfer will relocate the keys from the pocketbook into the crate.

ii. Then he will watch the shears and then very carefully grip the keys.

38i. The actress will insert the photo from the packaging into the notepad.

ii. Then she will locate the cake and then very promptly seize the photo.

39i. The gardener will lay the napkins from the clay pot into the lunch bag.

ii. Then he will notice the pizza and then very lazily handle the napkins.

40i. The author will shift the seeds from the packet into the jar.

ii. Then he will admire the gramophone and then very rapidly snatch the seeds.

Appendix E.1.2. Practice Sentences

41i. The singer will transport the glove from the golf bag into the wheelbarrow.

ii. Then she will examine the razor and then very swiftly carry the glove.

42i. The barman will replace the egg from the carton into the bucket.

ii. Then he will view the brush and then very cautiously hold the egg.

43i. The mechanic will swap the frozen meal from the shopping bag into the microwave.

ii. Then he will observe the carrots and then very hastily lift the frozen meal.

44i. The police officer will reposition the fruit from the cooler box into the package.

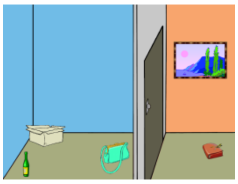
ii. Then she will detect the blackboard and then very gently take the fruit.

Appendix E.2. Visual Stimuli used in Experiment 6

There were 2 versions of each visual scene for each item, corresponding to the ‘Apart’ and ‘Together’ conditions, related to whether or not the source and goal location for the object were in the same or separate rooms respectively. For the pairs of images, those noted as ‘a’ depict the Apart condition, whereas those noted as ‘b’ depict the Together condition. The same restrictions used in the design of the items in Experiments 4 and 5 were used here, with all items corresponding to the experimental-type items used in Experiments 4 and 5, however half of the items (i.e. items 1-20) used doorway-type boundaries, and the other half (i.e. items 21-40) used line-type boundaries. Here, the practice items took the same form as the experimental items.

Appendix E.2.1. Experimental Scene Pairs

Appendix E.2.1.1. Doorway-type Boundaries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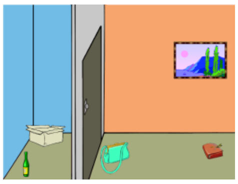
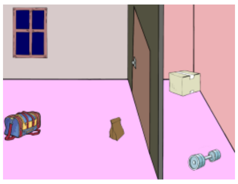
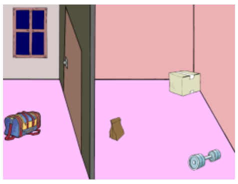

1b.


2a.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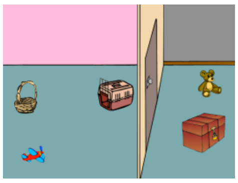
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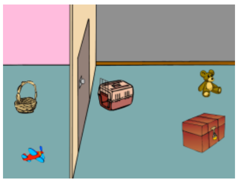
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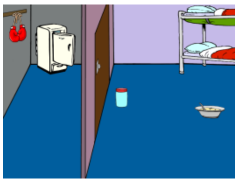
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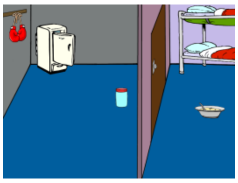
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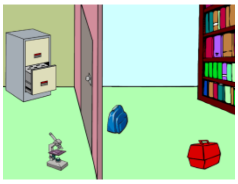
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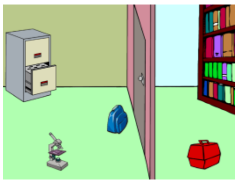
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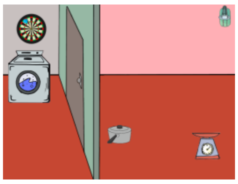
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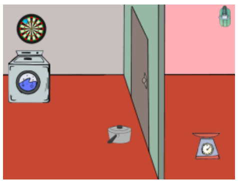
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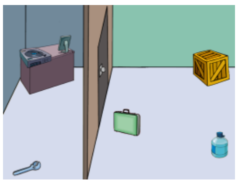
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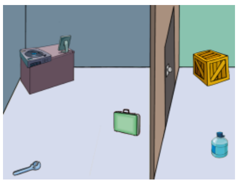
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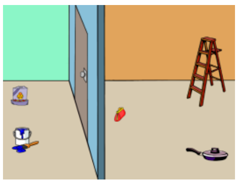
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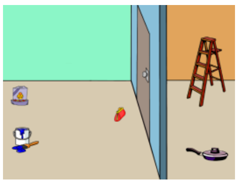
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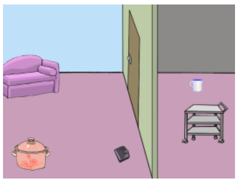
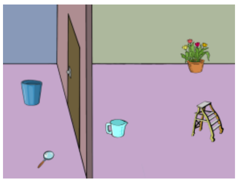
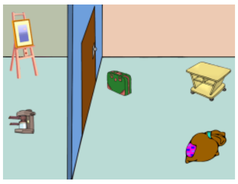
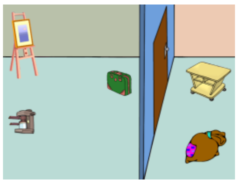
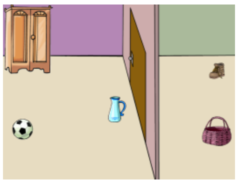
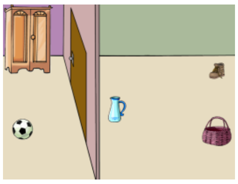
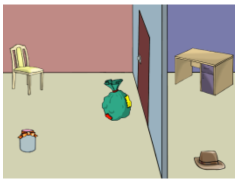
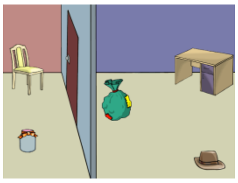
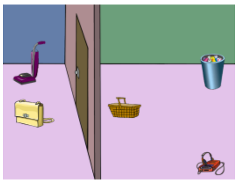
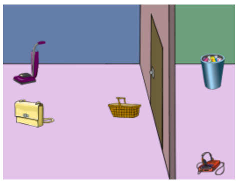
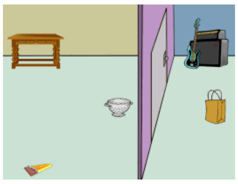
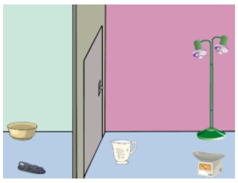
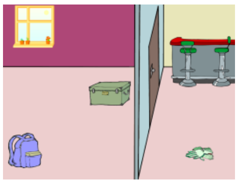
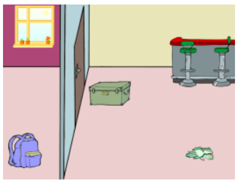
9a.  9b.  10a.  10b. 

11a.  11b.  12a.  12b. 

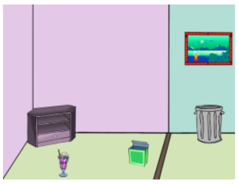
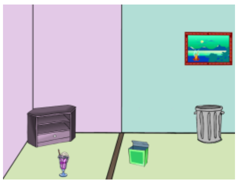
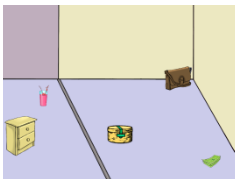
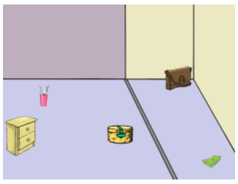
13a.  13b.  14a.  14b. 

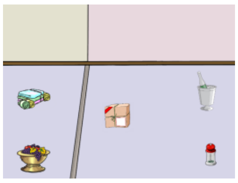
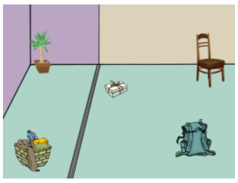
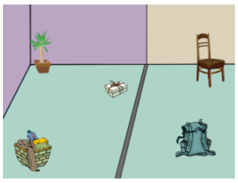
15a.  15b.  16a.  16b. 

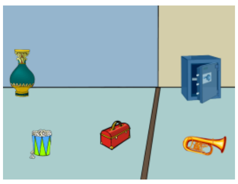
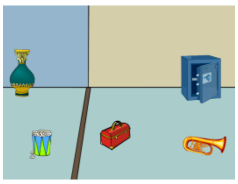
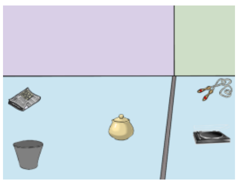
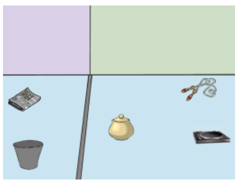
17a.  17b.  18a.  18b. 

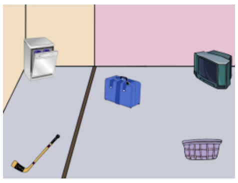
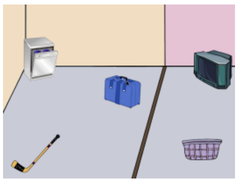
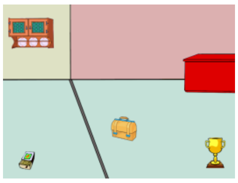
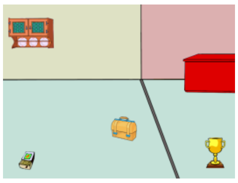
19a.  19b.  20a.  20b. 

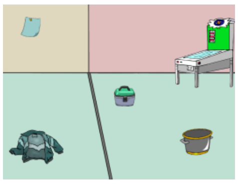
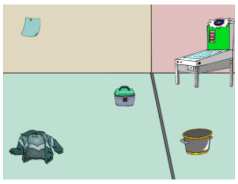
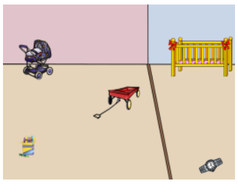
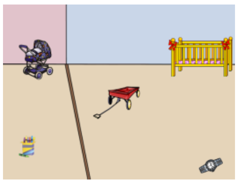
Appendix E.2.1.2. Line-type Boundaries

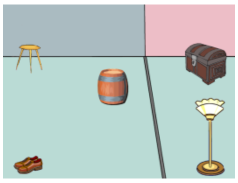
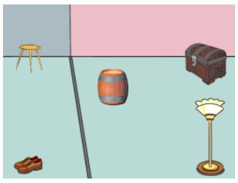
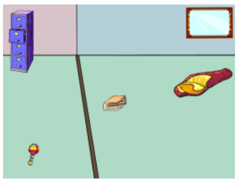
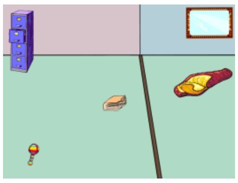
21a.  21b.  22a.  22b. 

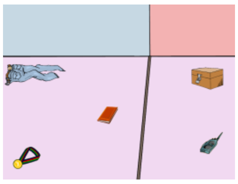
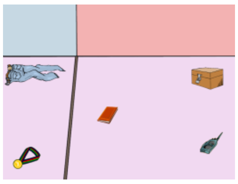
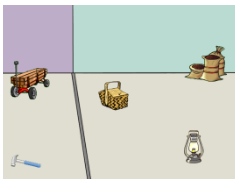
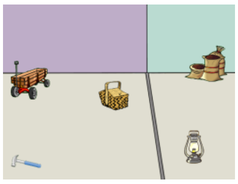
23a.  23b.  24a.  24b. 

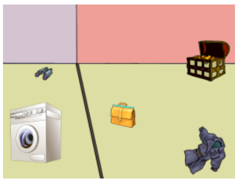
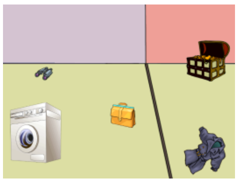
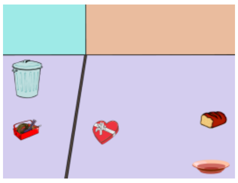
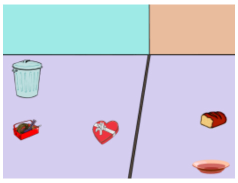
25a.  25b.  26a.  26b. 

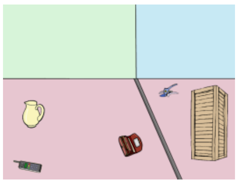
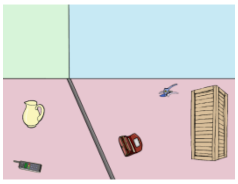
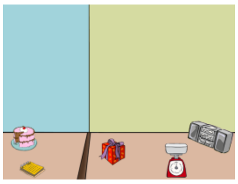
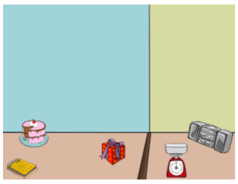
27a.  27b.  28a.  28b. 

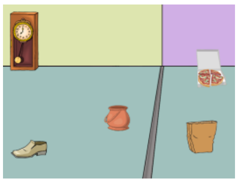
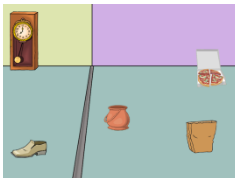
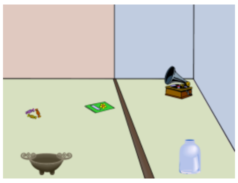
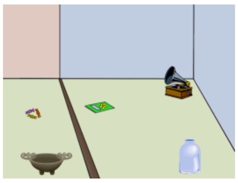
29a.  29b.  30a.  30b. 

31a.  31b.  32a.  32b. 

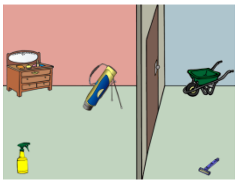
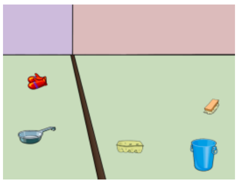
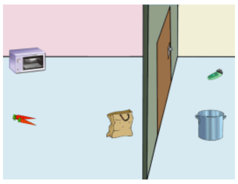
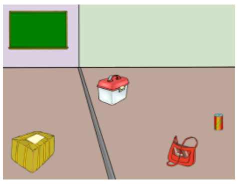
33a.  33b.  34a.  34b. 

35a.  35b.  36a.  36b. 

37a.  37b.  38a.  38b. 

39a.  39b.  40a.  40b. 

Appendix E.2.2. Practice Scenes

41.  42.  43.  44. 

Appendix E.3. Deviation Coding for Factors in Experiment 6

For both by-participants and by-items analyses, fixations were transformed using the empirical logit (`elog`), using a similar method outlined in Appendix A.3. In order to obtain main effects for each factor with two levels each (Condition (`condition`): Together, Apart; Boundary-type (`type`): Doorway, Line) deviation coding was used such that the baseline (0) for the model represented the grand mean of both factors, and the baseline for each factor was the average of both levels.

Deviation coding was computed as follows, creating a new numerical variable from the original treatment coded factors:

```
dt2$Conds <- ifelse(dt2$condition=="Apart",-.5,.5)

dt2$Bound <- ifelse(dt2$type=="Line",-.5,.5)
```

Appendix E.4. Models used for Analysis during the critical noun ('book') in Experiment 6

For both by-participants and by-items analyses, fixations were transformed using the empirical logit (`elog`), using a similar method outlined in Appendix A.3. Here, `elog` represents the proportion of fixations on the source, goal, or competitor depending on the analysis conducted. Both models contained fixed effects of the two deviation coded factors representing the two conditions, Condition (`Conds`) and Boundary-type (`Bound`), as well as fixed effects of time; using linear orthogonal (`ot1`) and quadratic polynomials (`ot2`). Departing from the method outlined in Appendix A.3, for the fixations on the source (book) the random effects structure was simplified to account for convergence failure in the model. To do so, random effects of participants/items were included for the intercept and both time terms, `(ot1+ot2 | by),` and the random effects of participants/items nested within condition and boundary type were included for the intercept `(1 | by:Conds:Bound)`, and for both time terms; `(0 + ot1 | by:Conds:Bound), (0 + ot2 | by:Conds:Bound)`; but the correlations amongst these nested random effects were removed. However, for fixations on the goal (table) no convergence failure was reported, as such the correlation between random effects was included in the model `(ot1 + ot2 | by:Conds:Bound)`. Similarly to Appendix A.3, the '`by`' factor took on the properties of participants/items depending upon the analysis used; hence the model structure is the same across both analyses even if its contents differ. In both, weights were calculated in a similar manner outlined in Appendix A.3.

Appendix E.4.1. Calculating the empirical logit for the (transformed) fixations on the source (handbag) and boundary (doorway/line) during the critical noun ('book') by-participants:

```
m.elog <- lmer(elog ~ (ot1+ot2)*Conds*Bound + (ot1+ot2 | by) +
(1 | by:Conds:Bound) + (0 + ot1 | by:Conds:Bound)  +
(0 + ot2 | by:Conds:Bound),data=df2, weights=1/wts, REML=FALSE)
```

Appendix E.4.2. Calculating the empirical logit for the (transformed) fixations on the goal (folder) during the critical noun ('book') by-participants:

```
m.elog <- lmer(elog ~ (ot1+ot2)*Conds*Bound + (ot1+ot2 | by) +
(ot1+ot2 | by:Conds:Bound),data=df2, weights=1/wts, REML=FALSE)
```

Appendix E.4.3. Calculating the empirical logit for the (transformed) fixations on the source (handbag), goal (folder), and boundary (doorway/line) during the critical noun ('book') by-items:

```
m.elog <- lmer(elog ~ (ot1+ot2)*Conds*Bound + (ot1+ot2 | by) +
(1 | by:Conds) + (0+ot1 | by:Conds) + (0+ot2 | by:Conds) + (1 | by:Bound) +
(0+ot1 | Bound) + (0+ot2 | Bound),data=df2, weights=1/wts, REML=FALSE)
```

Appendix F

Appendix F.1. Sentential Stimuli used in Experiment 7

There were 4 versions of each discourse for each experimental item, related to the location of the target relative to the competitor. The target and competitor could be described in the same location, i.e. in the Together condition, or in a different location, i.e. in the Apart condition. Moreover, the target could be mentioned in the most recently mentioned sentence or the first mentioned sentence, thus controlling for the order of mention for the target within items, and controlling for the association of the target and competitor with the two locations introduced within the narrative. In all items, 'ia' and 'ib' represent the Together condition, with the target mentioned in the first and second sentences (and locations) respectively, whereas 'ic' and 'id' represent the Apart condition, with the target mentioned in the first and second sentences (and locations) respectively. Experimental items mentioned the target again in sentence 'ii', however filler items took the same form for sentences in 'i', but instead mentioned a distractor in sentence 'ii'. The object mentioned again in sentence 'ii' was mentioned an equal number of times in the first, second, third, and fourth positions in sentence 'i' across all items. Practice items used two experimental-type and two filler-type items, specifically using Together condition version 'ia' and Apart condition version 'id' for the experimental-type items, and using condition version 'ib' and 'ic' for the filler-type items (again, however mentioning the distractor rather than the target). Filler items rotated across the same form as the four conditions used in the experimental items an equal number of times across items. Across all items, the target and competitor were equally related to each location. All experimental items took the form of the given example:

ia. The lock and the key are in the cafeteria. The ball and the melon are in the parlour.
ib. The ball and the melon are in the cafeteria. The lock and the key are in the parlour.
ic. The lock and the melon are in the cafeteria. The ball and the key are in the parlour.
id. The ball and the key are in the cafeteria. The lock and the melon are in the parlour.
ii. It seems that the lock is very old.

The underlined and italicised noun (e.g. *lock*) corresponds to the target object, and the underlined noun (e.g. key) corresponds to the competitor object. Following the conditions outlined above, these two objects could be in the together in the same location (i.e. Together condition; iia, b) or apart in separate locations (i.e. Apart condition; iic, d), rotating across the sentence and location the target and competitor were associated with.

The objects and locations were unique across all items. In sentence ‘ii’ half of the items began with the verb ‘it’ and were followed by a verb in another half of the items (e.g. ‘seems’), or by a verb phrase (e.g. ‘is said’) in the other half of the items. These forms were repeated using 4 phrases 8 times across all items. For the other half of the items, sentence ‘ii’ an adverb began the sentence (e.g. ‘Supposedly,’). These forms were repeated using 4 phrases 8 times across all items. For practice items, these phrases were unique, using three versions of the first form and one version of the second form.

Appendix F.1.1. Experimental Sentences

1ia. The lock and the key are in the cafeteria. The ball and the melon are in the parlour.
1ib. The ball and the melon are in the cafeteria. The lock and the key are in the parlour.
1ic. The lock and the melon are in the cafeteria. The ball and the key are in the parlour.
1id. The ball and the key are in the cafeteria. The lock and the melon are in the parlour.
1ii. It seems that the lock is very old.

2ia. The bat and the racket are in the park. The cigarette and the pear are in the dunes.
2ib. The cigarette and the pear are in the park. The bat and the racket are in the dunes.
2ic. The bat and the pear are in the park. The cigarette and the racket are in the dunes.
2id. The cigarette and the racket are in the park. The bat and the pear are in the dunes.
2ii. It appears that the bat is quite heavy.

3ia. The battery and the plug are in the lounge. The necklace and the map are in the high-street.
3ib. The necklace and the map are in the lounge. The battery and the plug are in the high-street.
3ic. The battery and the map are in the lounge. The necklace and the plug are in the high-street.
3id. The necklace and the plug are in the lounge. The battery and the map are in the high-street.
3ii. Apparently, the battery is strikingly powerful.

4ia. The skateboard and the bike are in the playroom. The coin and the porridge are in the student's union.
4ib. The coin and the porridge are in the playroom. The skateboard and the bike are in

the student's union.

4ic. The skateboard and the porridge are in the playroom. The coin and the bike are in the student's union.

4id. The coin and the bike are in the playroom. The skateboard and the porridge are in the student's union.

4ii. Seemingly, the skateboard is relatively small.

5ia. The wine and the grapes are in the base. The paint and the bagpipes are in the field.

5ib. The paint and the bagpipes are in the base. The wine and the grapes are in the field

5ic. The wine and the bagpipes are in the base. The paint and the grapes are in the field.

5id. The paint and the grapes are in the base. The wine and the bagpipes are in the field.

5ii. It is thought that the wine is expertly crafted.

6ia. The coat and the boot are in the office. The egg and the guitar are in the lighthouse.

6ib. The egg and the guitar are in the office. The coat and the boot are in the lighthouse.

6ic.The coat and the guitar are in the office. The egg and the boot are in the lighthouse.

6id. The egg and the boot are in the office. The coat and the guitar are in the lighthouse.

6ii. It is said that the coat is highly expensive.

7ia. The muffin and the cake are in the street. The glove and the accordion are in the kitchen.

7ib. The glove and the accordion are in the street. The muffin and the cake are in the kitchen.

7ic. The muffin and the accordion are in the street. The glove and the cake are in the kitchen.

7id. The glove and the cake are in the street. The muffin and the accordion are in the kitchen.

7ii. Allegedly, the muffin is exceedingly tasty.

8ia. The piano and the trumpet are in the bar. The carrot and the lantern are in the gallery.

8ib. The carrot and the lantern are in the bar. The piano and the trumpet are in the gallery.

8ic. The piano and the lantern are in the bar. The carrot and the trumpet are in the gallery.

8id. The carrot and the trumpet are in the bar. The piano and the lantern are in the gallery.

8ii. Supposedly, the piano is exceptionally rare.

9ia. The chair and the table are in the farm. The dumbbell and the poncho are in the yard.

9ib. The dumbbell and the poncho are in the farm. The chair and the table are in the yard.

9ic. The chair and the dumbbell are in the farm. The table and the poncho are in the yard.

9id. The table and the poncho are in the farm. The chair and the dumbbell are in the yard.

9ii. It seems that the chair is incredibly dated.

10ia. The banana and the coconut are in the hallway. The rug and the lighter are in the ticket office.

10ib. The rug and the lighter are in the hallway. The banana and the coconut are in the ticket office.

10ic. The banana and the rug are in the hallway. The coconut and the lighter are in the ticket office.

10id. The coconut and the lighter are in the hallway. The banana and the rug are in the ticket office.

10ii. It appears that the banana is perfectly ripe.

11ia. The stapler and the glue are in the front room. The dart and the card are in the workshop.

11ib. The dart and the card are in the front room. The stapler and the glue are in the workshop.

11ic. The stapler and the dart are in the front room. The glue and the card are in the workshop.

11id. The glue and the card are in the front room. The stapler and the dart are in the workshop.

11ii. Apparently, the stapler is always broken.

12ia. The sausage and the bacon are in the hairdressers. The calculator and the doorstop are in the recording studio.

12ib. The calculator and the doorstop are in the hairdressers. The sausage and the bacon are in the recording studio.

12ic. The sausage and the calculator are in the hairdressers. The bacon and the doorstop are in the recording studio.
12id. The bacon and the doorstop are in the hairdressers. The sausage and the calculator are in the recording studio.
12ii. Seemingly, the sausage is extremely appetising.

13ia. The hammer and the nail are in the warehouse. The snorkel and the couch are in the spa. 13ib. The snorkel and the couch are in the warehouse. The hammer and the nail are in the spa.
13ic. The hammer and the snorkel are in the warehouse. The nail and the couch are in the spa. 13id. The nail and the couch are in the warehouse. The hammer and the snorkel are in the spa.
13ii. It is thought that the hammer is considerably worn.

14ia. The sandwich and the butter are in the restaurant. The medicine and the cork are in the arcade.
14ib. The medicine and the cork are in the restaurant. The sandwich and the butter are in the arcade.
14ic. The sandwich and the medicine are in the restaurant. The butter and the cork are in the arcade.
14id. The butter and the cork are in the restaurant. The sandwich and the medicine are in the arcade.
14ii. Allegedly, the sandwich is absolutely delicious.

15ia. The shirt and the trousers are in the nursery. The computer and the flower are in the lodge.
15ib. The computer and the flower are in the nursery. The shirt and the trousers are in the lodge.
15ic. The shirt and the computer are in the nursery. The trousers and the flower are in the lodge.
15id. The trousers and the flower are in the nursery. The shirt and the computer are in the lodge.
15ii. It is said that the shirt is beautifully made.

16ia. The potato and the celery are in the club house. The lipstick and the notepad are in the garden.
16ib. The lipstick and the notepad are in the club house. The potato and the celery are in

the garden.

16ic. The potato and the lipstick are in the club house. The celery and the notepad are in the garden.

16id. The celery and the notepad are in the club house. The potato and the lipstick are in the garden.

16ii. Supposedly, the potato is especially flavourful.

17ia. The jar and the bottle are in the reception. The typewriter and the acorn are in the library.

17ib. The typewriter and the acorn are in the reception. The jar and the bottle are in the library.

17ic. The typewriter and the bottle are in the reception. The jar and the acorn are in the library.

17id. The jar and the acorn are in the reception. The typewriter and the bottle are in the library.

17ii. It appears that the bottle is really big.

18ia. The screw and the drill are in the garage. The crayon and the mustard are in the shed.

18ib. The crayon and the mustard are in the garage. The screw and the drill are in the shed.

18ic. The crayon and the drill are in the garage. The screw and the mustard are in the shed.

18id. The screw and the mustard are in the garage. The crayon and the drill are in the shed.

18ii. Apparently, the drill is normally missing.

19ia. The jam and the toast are in the train station. The microphone and the chalk are in the club.

19ib. The microphone and the chalk are in the train station. The jam and the toast are in the club.

19ic. The microphone and the toast are in the train station. The jam and the chalk are in the club.

19id. The jam and the chalk are in the train station. The microphone and the toast are in the club.

19ii. It seems that the toast is mostly stale.

20ia. The cutters and the hacksaw are in the pharmacy. The umbrella and the jelly are in the campus.
20ib. The umbrella and the jelly are in the pharmacy. The cutters and the hacksaw are in the campus.
20ic. The umbrella and the hacksaw are in the pharmacy. The cutters and the jelly are in the campus.
20id. The cutters and the jelly are in the pharmacy. The umbrella and the hacksaw are in the campus.
20ii. Seemingly, the hacksaw is awfully sharp.

21ia. The money and the wallet are in the resort. The burger and the goggles are in the porch.
21ib. The burger and the goggles are in the resort. The money and the wallet are in the porch.
21ic. The burger and the wallet are in the resort. The money and the goggles are in the porch.
21id. The money and the goggles are in the resort. The burger and the wallet are in the porch.
21ii. It is thought that the wallet is astonishingly pricey.

22ia. The milk and the cheese are in the foyer. The sock and the torch are in the teacher's lounge.
22ib. The sock and the torch are in the foyer. The milk and the cheese are in the teacher's lounge.
22ic. The sock and the cheese are in the foyer. The milk and the torch are in the teacher's lounge.
22id. The milk and the torch are in the foyer. The sock and the cheese are in the teacher's lounge.
22ii. It is said that the cheese is uncommonly strong.

23ia. The spoon and the cup are in the rugby club. The plant and the book are in the airport.
23ib. The plant and the book are in the rugby club. The spoon and the cup are in the airport.
23ic. The plant and the cup are in the rugby club. The spoon and the book are in the airport.

23id. The spoon and the book are in the rugby club. The plant and the cup are in the airport.
23ii. It is thought that the cup is notably fragile.

24ia. The drum and the violin are in the meadow. The sandal and the pumpkin are in the grounds.
24ib. The sandal and the pumpkin are in the meadow. The drum and the violin are in the grounds.
24ic. The sandal and the violin are in the meadow. The drum and the pumpkin are in the grounds.
24id. The drum and the pumpkin are in the meadow. The sandal and the violin are in the grounds.
24ii. Supposedly, the violin is massively extravagant.

25ia. The pan and the kettle are in the hotel. The speaker and the compass are in the pub.
25ib. The speaker and the compass are in the hotel. The pan and the kettle are in the pub.
25ic. The compass and the kettle are in the hotel. The speaker and the pan are in the pub.
25id. The speaker and the pan are in the hotel. The compass and the kettle are in the pub.
25ii. It seems that the kettle is almost brand-new.

26ia. The ink and the pencil are in the mine. The spade and the feather are in the carpark.
26ib. The spade and the feather are in the mine. The ink and the pencil are in the carpark.
26ic. The feather and the pencil are in the mine. The spade and the ink are in the carpark.
26id. The spade and the ink are in the mine. The feather and the pencil are in the carpark.
26ii. Supposedly, the pencil is too blunt.

27ia. The brick and the trowel are in the toilets. The strawberry and the radio are in the staff room.
27ib. The strawberry and the radio are in the toilets. The brick and the trowel are in the

staff room.

27ic. The radio and the trowel are in the toilets. The strawberry and the brick are in the staff room.

27id. The strawberry and the brick are in the toilets. The radio and the trowel are in the staff room.

27ii. Apparently, the trowel is surprisingly tiny.

28ia. The tomato and the lettuce are in the craft room. The rope and the phone are in the greenhouse.

28ib. The rope and the phone are in the craft room. The tomato and the lettuce are in the greenhouse.

28ic. The phone and the lettuce are in the craft room. The rope and the tomato are in the greenhouse.

28id. The rope and the tomato are in the craft room. The phone and the lettuce are in the greenhouse.

28ii. Seemingly, the lettuce is altogether crisp.

29ia. The letter and the envelope are in the bistro. The cap and the pancake are in the shop.

29ib. The cap and the pancake are in the bistro. The letter and the envelope are in the shop.

29ic. The pancake and the envelope are in the bistro. The cap and the letter are in the shop.

29id. The cap and the letter are in the bistro. The pancake and the envelope are in the shop.

29ii. It appears that the envelope is securely sealed.

30ia. The orange and the apple are in the retail park. The ticket and the calendar are in the villa.

30ib. The ticket and the calendar are in the retail park. The orange and the apple are in the villa.

30ic. The calendar and the apple are in the retail park. The ticket and the orange are in the villa.

30id. The ticket and the orange are in the retail park. The calendar and the apple are in the villa.

30ii. It is said that the apple is remarkably sweet.

31ia. The trophy and the medal are in the stock room. The sushi and the pipe are in the gymnasium.
31ib. The sushi and the pipe are in the stock room. The trophy and the medal are in the gymnasium.
31ic. The pipe and the medal are in the stock room. The sushi and the trophy are in the gymnasium.
31id. The sushi and the trophy are in the stock room. The pipe and the medal are in the gymnasium.
31ii. Allegedly, the medal is curiously light.

32ia. The jacket and the tie are in the barber's shop. The ruler and the keyboard are in the car dealership.
32ib. The ruler and the keyboard are in the barber's shop. The jacket and the tie are in the car dealership.
32ic. The keyboard and the tie are in the barber's shop. The ruler and the jacket are in the car dealership.
32id. The ruler and the jacket are in the barber's shop. The keyboard and the tie are in the car dealership.
32ii. Allegedly, the tie is decidedly thick.

Appendix F.1.2. Filler Sentences

33i. The flour and the bread are in the classroom. The mouse and the headphones are in the off-licence.
33ii. It seems that the mouse is highly accurate.

34i. The flag and the mirror are in the treasury. The bone and the skull are in the archives.
34ii. It appears that the flag is quite thin.

35i. The camera and the scales are in the taxi rank. The hat and the film are in the coffee shop.
35ii. Apparently, the hat is relatively cheap.

36i. The earring and the newspaper are in the factory. The magazine and the pineapple are in the theatre.
36ii. Seemingly, the earring is strikingly weighty.

37i. The beer and the whisky are in the museum. The handbag and the stopwatch are in the lobby.
37ii. It is thought that the handbag is expertly designed.

38i. The cactus and the plunger are in the cathedral. The sword and the armour are in the tourist office.
38ii. It is said that the cactus is awfully spiky.

39i. The gun and the monitor are in the surf shop. The bullet and the painting are in the box office.
39ii. Allegedly, the monitor is exceptionally bright.

40i. The jeans and the noodles are in the driveway. The underwear and the stamp are in the stadium.
40ii. Supposedly, the stamp is notably remarkable.

41i. The kite and the balloon are in the supermarket. The football and the shovel are in the back yard.
41ii. It seems that the shovel is massively cumbersome.

42i. The gramophone and the rucksack are in the playground. The fork and the bowl are in the carvery.
42ii. It appears that the rucksack is securely fastened.

43i. The steak and the blanket are in the charity shop. The pillow and the leaf are in the mansion.
43ii. Apparently, the leaf is very dry.

44i. The knife and the clock are in the cottage. The slingshot and the razor are in the corner shop.
44ii. It appears that the clock is extremely slow.

45i. The blouse and the shorts are in the outlet store. The hotdog and the megaphone are in the fair.
45ii. It is thought that the megaphone is considerably loud.

46i. The badge and the mascara are in the mall. The surfboard and the oar are in the corridor.
46ii. It seems that the mascara is absolutely exquisite.

47i. The lamp and the corn are in the greengrocers. The helmet and the wheat are in the woods.
47ii. Allegedly, the lamp is beautifully finished.

48i. The domino and the campfire are in the forest. The soap and the tent are in the swamp.
48ii. Supposedly, the soap is remarkably scented.

49i. The scissors and the cardboard are in the drawing room. The tart and the mitten are in the tennis courts.
49ii. It is said that the tart is really tempting.

50i. The toothpaste and the handcuffs are in the guard tower. The pot and the saucepan are in the security office.
50ii. Seemingly, the toothpaste is uncommonly overpriced.

51i. The mallet and the swimsuit are in the tanning salon. The honey and the vice are in the laundry room.
51ii. Apparently, the honey is especially horrible.

52i. The mug and the chisel are in the waiting room. The pliers and the dice are in the vault.
52ii. Seemingly, the mug is always dirty.

53i. The chocolate and the pizza are in the school. The wand and the stone are in the basement.
53ii. It is thought that the wand is curiously flimsy.

54i. The avocado and the microscope are in the observatory. The bell and the whistle are in the school yard.
54ii. It is said that the avocado is altogether unripe.

55i. The pie and the monocle are in the show room. The salad and the bandage are in the food hall.
55ii. Allegedly, the monocle is exceedingly fancy.

56i. The headband and the teapot are in the oil rig. The vest and the rivet are in the exercise yard.
56ii. Supposedly, the rivet is incredibly tough.

57i. The custard and the biscuit are in the dental surgery. The puppet and the yo-yo are in the vineyard.
57ii. It seems that the yo-yo is surprisingly fast.

58i. The postcard and the axe are in the construction site. The shampoo and the comb are in the grassland.
58ii. It appears that the axe is perfectly weighted.

59i. The mace and the chips are in the arena. The ketchup and the belt are in the dressing room.
59ii. Apparently, the belt is too long.

60i. The nut and the fish are in the computer shop. The crown and the bolt are in the city centre.
60ii. Seemingly, the fish is mostly cooked.

61i. The clarinet and the saxophone are in the practice room. The ashtray and the printer are in the distillery.
61ii. It is thought that the printer is almost malfunctioning.

62i. The vase and the syringe are in the alley. The motorcycle and the car are in the cemetery.
62ii. It is said that the syringe is decidedly large.

63i. The sunflower and the boat are in the lockup. The handbook and the dinghy are in the avenue.
63ii. Allegedly, the sunflower is normally flourishing.

64i. The screwdriver and the matches are in the changing room. The tiara and the candle are in the stables.
64ii. Supposedly, the tiara is astonishingly valuable.

Appendix F.1.3. Practice Sentences

65i. The spaghetti and the mayonnaise are in the boulevard. The cape and the paintbrush are in the town square.
65ii. It is thought that the spaghetti is genuinely flavoursome.

66i. The beanbag and the crutch are in the common room. The floss and the toothbrush are in the ice-rink.

66ii. It is known that the crutch is severely unstable.

67i. The desk and the javelin are in the quarry. The blackboard and the cocktail are in the layby.

67ii. It is believed that the blackboard is utterly defective.

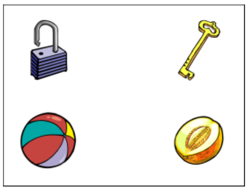
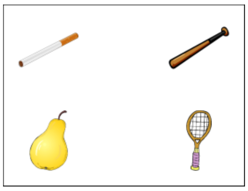
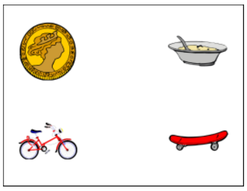
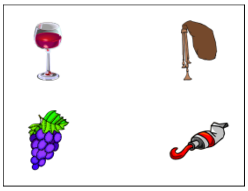
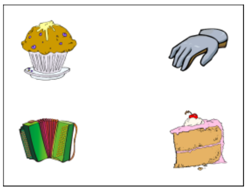
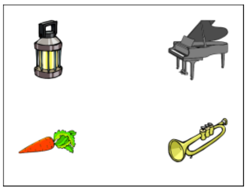
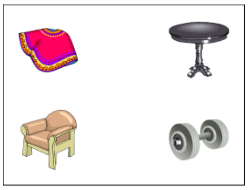
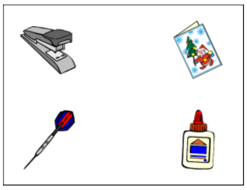
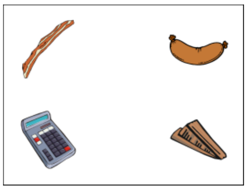
68i. The scarf and the quiche are in the bank. The cereal and the wheel are in the laboratory.

68ii. Presumably, the wheel is totally new.

Appendix F.2. Visual Stimuli used in Experiment 7

All visual stimuli displayed here are scaled down from the original 800 x 600 pixels. Visual stimuli were displayed with a 200 pixel grey border around the perimeter. All stimuli below have an added black border for ease of viewing due to the use of a white background; however this was not included in the experiment due to the inclusion of the 200 pixel grey border. Across items, the target, competitor, and two distractors were located in each corner of the visual display an equal number of times using a pseudo-random order.

Appendix F.2.1. Experimental Scenes

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 
9. 
10. 
11. 
12. 

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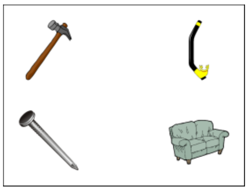

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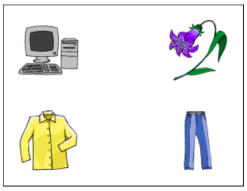

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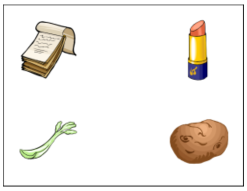

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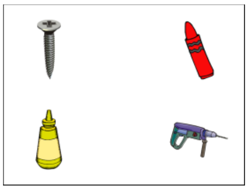

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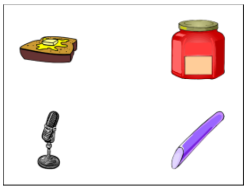

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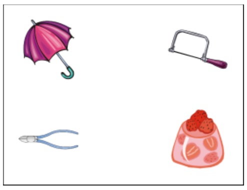

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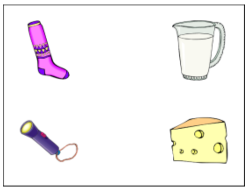

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25.


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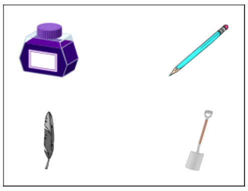

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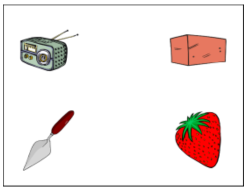

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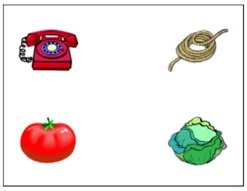

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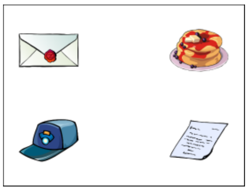

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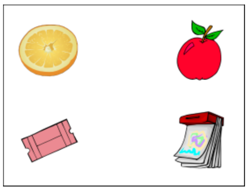

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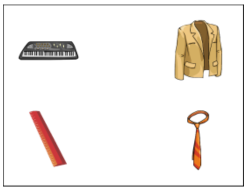

Appendix F.2.2. Filler Scenes

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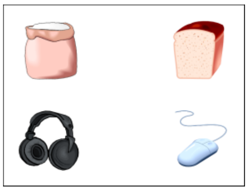

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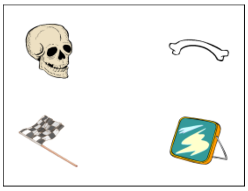

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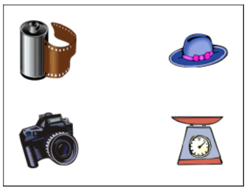

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37.


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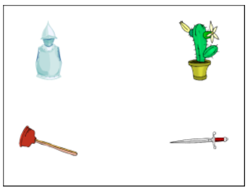

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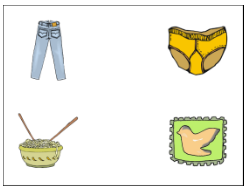

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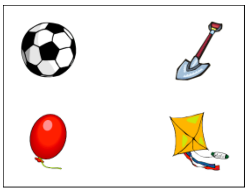

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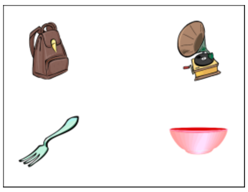

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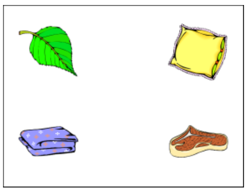

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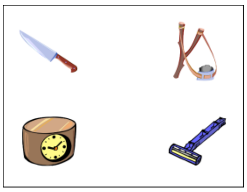
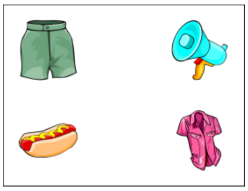
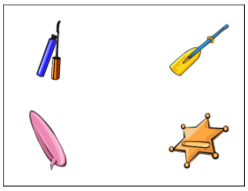
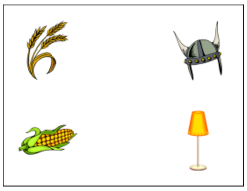
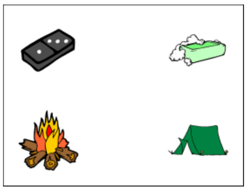


45. 
46. 
47. 
48. 

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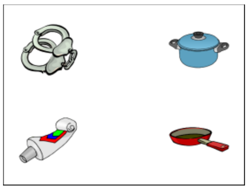
50. 
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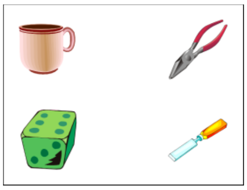
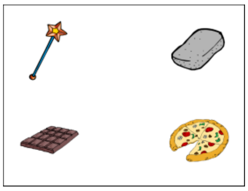
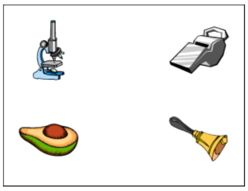
52. 

53. 
54. 
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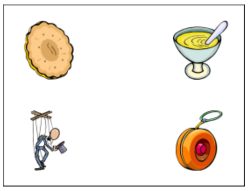
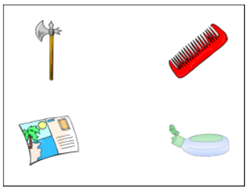
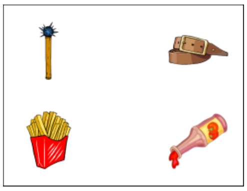
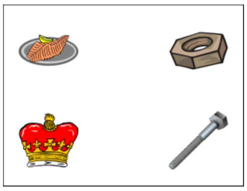
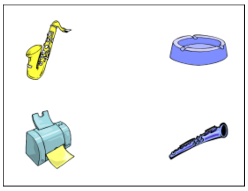
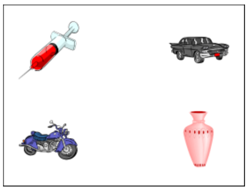
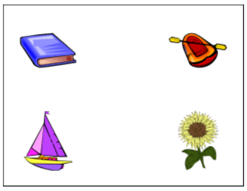
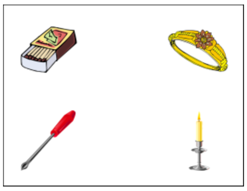
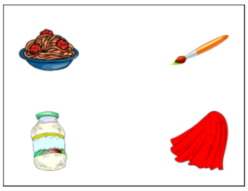
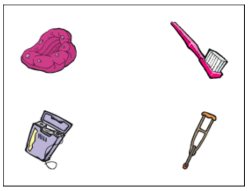
57. 
58. 
59. 
60. 

61. 
62. 
63. 
64. 

Appendix F.2.3. Practice Scenes

65. 
66. 
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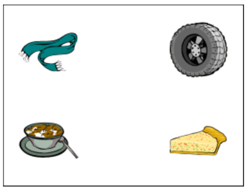
68. 

Appendix F.3. Models used for Analysis in Experiment 7

Across all analyses, including both by-participants and by-items analyses, fixations were transformed using the empirical logit (`elog`), using a similar method outlined in Appendix 2a.

For all analyses both models contain fixed effects of time; using orthogonal linear (`ot1`) or quadratic (`ot2`) polynomials where appropriate: Specific time-terms are outlined in each sub-heading for each analysis. When comparing the fixations on each object split by condition (Appendix F.3.1 and Appendix F.3.3), both by-participants and by-items models also contained fixed effects of interest area (`IA2`). Here, models contained random effects (and their correlations) of participants/items (`by`) and participants/items by interest area (`by: IA2`) on the relevant time terms. The '`by`' factor took on the properties of participants/items depending upon the analysis used; hence the model structure is the same across both analyses even if its contents differ. When comparing the fixations each object by condition (Appendix 5.1.3.1.3), both by-participants and by-items models also contained fixed effects of condition (`condition`). Here, models contained random effects (and their correlations) of participants/items (`by`) and participants/items by condition (`by: condition`) on the relevant time terms. Again, the '`by`' factor took on the properties of participants/items depending upon the analysis used.

Across both time-windows, for the analyses comparing fixations on each object split by condition(Appendix F.3.1 and Appendix F.3.3), *p*-values were calculated in a similar manner to that in 0**,** requiring multiple comparisons due to the '`IA2`' factor containing more than 2 levels. In these cases, a subset of the data containing only one condition was acquired by creating a new data table containing the data from the selected condition as follows:

```
dt3 <- dt2[condition=="together",]
```

or

```
dt3 <- dt2[condition=="apart",]
```

Following this, the data from this data table was prepared into a data frame (`df3`) prior to analysis. For the analyses comparing fixations on each object by condition (Appendix 5.1.3.1.3), *p*-values were calculated in a similar manner to that in Appendix C.5, using the normal approximation due to the condition factor containing only 2 levels, with no sub-setting involved.

Appendix F.3.1. Calculating the empirical logit for the (transformed) fixations on the target (lock), competitor (key) and distractor (ball, melon) split by condition (Apart, Together) 200ms after the onset until 200ms after the offset of the critical noun ('lock'):

Appendix F.3.1.1. Calculations for the Apart and Together conditions

```
m.elog <- lmer(elog ~ ot1*IA2 + (ot1|by) + (ot1|by:IA2), data=df3,
weights=1/wts, REML=FALSE)
```

Appendix F.3.2. Calculating the empirical logit for the (transformed) fixations on each object (e.g. target, competitor, and distractor) individually in the Together vs. Apart conditions for both time-windows:

Appendix F.3.2.1. Calculations for the target (lock) and distractor (ball, melon)

```
m.elog <- lmer(elog ~ ot1*condition + (ot1 | by) + (ot1 |
by:condition),data=df2, weights=1/wts, REML=FALSE)
```

Appendix F.3.2.2. Calculations for the competitor (key)

```
m.elog <- lmer(elog ~ (ot1+ot2)*condition + (ot1+ot2|by) +
(ot1+ot2|by:condition), data=df2, weights=1/wts, REML=FALSE)
```

Appendix F.3.3. Calculating the empirical logit for the (transformed) fixations on the target (lock), competitor (key) and distractor (ball, melon) split by condition (Apart, Together) 300ms after the onset of the critical noun ('lock') until the offset of the spillover region ('is'):

Appendix F.3.3.1. Calculations for the Together condition

```
m.elog <- lmer(elog ~ ot1*IA2 + (ot1 |by) + (ot1|by:IA2), data=df3,
weights=1/wts, REML=FALSE)
```

Appendix F.3.3.2. Calculations for the Apart condition

```
m.elog <- lmer(elog ~ (ot1+ot2)*IA2 + (ot1+ot2|by) + (ot1+ot2|by:IA2),
data=df3, weights=1/wts, REML=FALSE)
```